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A Study of Achievement and Subject Matter in General Science

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CHAPTER VII.

RELIABILITY OF THE GENERAL SCIENCE SCALE.

The three Forms of the General Science Scale containing sixty items each were selected from the 300 items which composed the original General Science test. The question might arise why the particular items which compose the three Forms were selected in preference to the items which were discarded. Of the total number of 300 items, 180 items were retained. One hundred and twenty items were eliminated and were not even used for the composition of additional Forms of the General Science test for three reasons.

(1) The items of a Scale Form follow a regular sequence of steps or levels of difficulty one-tenth of a P. E. apart. Reference to Table II shows that there was a large number of items near the middle of the range of difficulty, i. e., at about 8.0 P. E. above zero, with a dearth of items at either extreme of the range. In order to have Scale Forms each with a range of 3 P. E., it was necessary to start one Form with items at 5.7 P. E. and two Forms with items at 6.7 P. E. This process took six items at each level of difficulty between 6.7 P. E. and 8.6 P. E., and as a result all the items at some levels had been exhausted. There are, therefore, three forms of the scale which are entirely different in material. To have made another form would have meant using some items in two or more forms. This was thought undesirable. While 120 items still remained, they were not of such difficulty or value as to form even one sequence of sixty items over a range of 3 P. E. As had been anticipated during the construction of the original General Science test, all of this original material could not be used. This instead of being a calamity was really quite fortunate.

(2) The elimination of certain items permitted a scientific selection of items. As has been stated, certain objectives of General Science were to be kept in mind in the construction of the Scale. No item was to be retained in the final Scale, the achievement of which by pupils did not contribute to the objectives of General Science as previously outlined. It would have been deemed advisable to use material from but one specific field of science if that material seemed to contribute *most* towards the objectives of General Science. In the writer's opinion, the science material which contributes most towards the objectives of General Science is a mass of elementary, fundamental material which several decades ago might well have come under the heading "Natural Philosophy" or which today is classified by a number of research men in various fields of science as material which "commonsense should make apparent." The frequency with which many of the items in the General Science test were done unsuccessfully by high school pupils indicates the fallacy of the latter characterization, unless one were to assume a paucity of "commonsense."

An analysis of the 180 items selected for the Scale Forms results in a grouping of the following numbers of items under eight specialized sciences.

TABLE III

Distribution of Items of Three Scale Forms under Eight Specialized Sciences

		Number of Items		
SCIENCES	*Scale Forms—*	R-1	S-2	T-2
1.	Botany	4	6	7
2.	Chemistry	4	8	6
3.	Domestic Science	3	2	2
4.	Geography*	3	7	8
5.	Hygiene	15	5	5
6.	Physics	20	21	23
7.	Physiology	6	3	4
8.	Zoology	5	8	5
	Total	60	60	60

While another person classifying these same items might make a slightly different classification than the one which is given above, the above classification is an indication of the

* Geography is considered in its widest sense—including even Astronomy, Geology and Physiography.

fairly uniform distribution of the items among the basic sciences. An item like "Flies lay their eggs *in wood, on the water, in animal and vegetable waste, in nests, in the sand,*" might be classed either as Zoology or as Hygiene. Irrespective of the science to which it belongs, knowing it contributes to "Health" and makes it a good General Science item. In connection with the classification of General Science items, Webb's data[1] which have been previously cited (see Chap. III), are apropos.

(3) It was found that some of the items inserted in the original General Science test were ambiguous or weak or not sufficiently objective. These items, therefore, were discarded because of their structural inefficiency.

Examination of many of the items in the General Science Scale shows that ordinarily some of them would be taught in as many as three or four specialized sciences. "Capillarity," for instance, is legitimate subject matter for Physics, Chemistry, Botany, Agriculture, Physiology and Zoology. Likewise the effect of air pressure (Boyle's Law) is usually legitimate subject matter for Physics, Chemistry, Domestic Science and perhaps Biology. In other words, certain subject matter is fundamental to several specialized sciences. Usually teachers of these more advanced and specialized sciences cannot take for granted the possession of these fundamentals by their students, therefore each teacher duplicates the instruction. This fundamental material in General Science, besides being a prerequisite for more advanced sciences, fulfills the objectives of General Science.

The subject matter of the original General Science test was considered by at least a dozen General Science teachers to be so inclusive that they have asked for permission to include the General Science test material in their course of study, subdividing it and using its various items as a skeleton for various parts of the course. Therefore, while it is understood that other material might have been included in the Scale, it is believed that the material actually included, if it satisfies other requirements, is adequately varied and adequately inclusive.

B. CORRELATION WITH ORIGINAL GENERAL SCIENCE TEST.

In a previous chapter evidence has been presented which showed that the original 300 item test had unexpected relia-

bility, as evidenced by its correlation with certain criteria of General Science ability. The original test would therefore serve as one criterion for ascertaining the reliability of the final Scale. With that purpose in mind a number of the original 300 item papers, selected at random by taking the first 100 in each grade for the five grades of boys who had not had General Science (8th, 9th, 10th, 11th and 12th grades), were rescored on the basis of Form S-2. That is, the original 300 item papers contained the 60 items which now comprise the Form S-2. By counting up the errors on those 60 particular items, it was possible to give each paper an S-2 Scale Score which indicated the pupil's achievement on the 60 items, which comprise Scale Form S-2. The 300 item test scores were correlated with their S-2 Scale scores by the product-moment method. The coefficients of correlation ranged from .81 to .93 for the five grade groups.

For			
49	—8th grade boys, Test and Scale scores, r equals	.87	P. E. .02
100	—9th grade boys, Test and Scale scores, r equals	.93	P. E. .01
100	—10th grade boys, Test and Scale scores, r equals	.90	P. E. .01
100	—11th grade boys, Test and Scale scores, r equals	.905	P. E. .01
100	—12th grade boys, Test and Scale scores, r equals	.81	P. E. .02
	Mean......	.882	P. E. .015*

From these coefficients of correlation it is evident that if the original test had fair reliability, the abbreviated Form of the original test (Scale Form S-2), having exceptionally high agreement with the original test, must, therefore, approximate the original test in its reliability. Evidence will be presented later that the Scale Form S-2 actually was more reliable than the original test. That these coefficients are not higher, is largely due to the errors of the *test*.

C. CORRELATION AND AGREEMENT OF TEST AND SCALE MEDIANS.

Additional data obtained in the study of corelation between test and Scale are also significant. In Chapter VI it was indicated that when the rank order of difficulty for any item had been secured from as many as 215 papers, adding 215 papers did not materially change its relative position, as evidenced by a rank order correlation coefficient of .98 between a rank

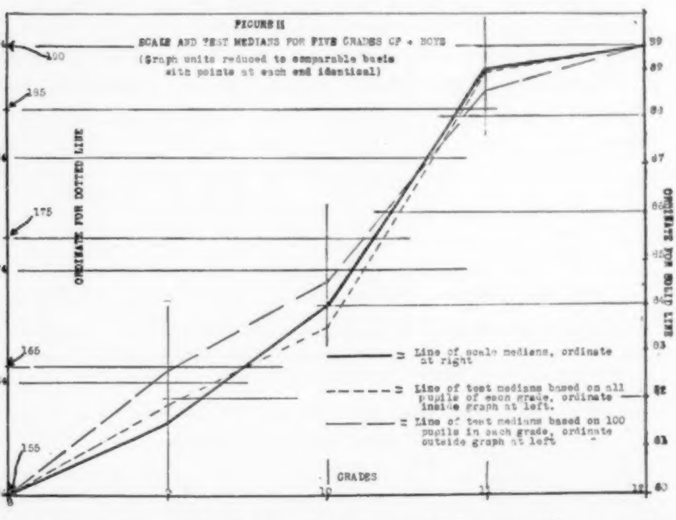
* P. E. of r when r equals .882, not a mean.

order on 215 papers and a rank order on 430 papers. In this part of the study it was found that by taking 100 papers in each grade group, the medians for the five groups of 100 papers each did not differ from the medians on as many as 500 papers by as much as an average of one-sixth P. E. of the distribution. The P. E.s of the medians of distributions having 500 cases with a P. E. of distribution of 22 were *one point*. The P. E.s of medians of the distributions having 100 cases with P. E.s of distribution of 22 were *two points*.

TEST AND SCALE MEDIANS.

	On original group		300 Item Test On 100 cases		Scale S-2 On 100 cases	
	A	Sigma	B	Sigma	C	Sigma
+8 Boys	155	31.5	154	26.7	80	5.5
+9 Boys	162	33	165	34	81.5	7.1
+10 Boys	168	33	173	34	84	6.5
+11 Boys	188	28.5	190	28	89	6.1
+12 Boys	190	22.5	194	25.4	89.5	5.5

The coefficients of correlation between the medians of columns A and C and of columns B and C are .993 and .986 respectively. Further evidence of the marked agreement between the test and Scale scores is given in Figure II.



It is clear from this figure that it would be possible to make up a table of scale scores and their corresponding test scores

which would enable one immediately to translate a scale score into a test score and vice versa. In Figure II three systems of ordinates of varying lengths have been arranged in such manner that the extremes of all curves coincide. Lack of agreement among the three sets of medians must therefore appear in divergence of the central parts of the curves. Reference to these data will again be made in Chapter VIII.

D. SELF-CORRELATION.

Since Scale S-2 and Scale T-2 were constructed to be of identical difficulty, both these Forms were given to a number of pupils to ascertain the agreement between them. School A (Stillwater, Minnesota) gave the two Scale Forms to 140 pupils who were taking General Science and had completed thirty weeks of the course. Results follow.

SCHOOL A.

	Form S-2	Form T-2	
Number cases	140	140	
Median	92	86	
Sigma	6.1	4.1	
P. E. of estimate*	2.8	1.9	
P. E. of median†	.6	.4	
r	.70	P. E. of r	.03

Had the two Forms of the Scale been twice as long or had the combined results of two repetitions of the same Forms been secured, r would have equalled .903.‡

The same Scale Forms were given to two groups of School B (University High School) pupils, all of whom had been taking General Science for thirty weeks, for the first time. Their results were:

SCHOOL B (First Group).

	Form S-2	Form T-2	
Number cases	24	24	
Median	87	87	
Sigma	5.8	4.7	
P. 5. of estimate	2.4	2	
P. E. of median	1.4	1.2	
r	.77	P. E. of r	.05

Had the two Forms of the Scale been twice as long or had the combined results of two repetitions of the same Forms been secured, r would have equalled .93.

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* P. E. of estimate equals .6745 Sigma $\sqrt{1-r^2}$

† P. E. of median equals $\dfrac{.6745 \quad 1\frac{1}{4}\text{ S. D. Distribution}}{\sqrt{\text{No. cases}}}$

‡ Brown's formula: $r_{.}$ equals $\dfrac{Nr}{1+(N-1)r}$ where N equals number of repetitions and r_1 equals desired coefficient of reliability.

SCHOOL B (Second Group).

	Form S-2	Form T-2
Number cases	34	34
Median	84	82
Sigma	5.8	4.0
P. E. of estimate	2.6	1.9
P. E. of median	1.2	.8
r	.71	P. E. of r .... .05

Had the two Forms of the Scale been twice as long or had the combined results of two repetitions of the same Forms been secured, r would have equalled .915.

These data show that as a device for measuring the pupils' achievement in General Science, the Scale Forms have fair reliability, as is shown by an average self correlation coefficient of .73 and an average P. E. of estimate of 2.2. As a device for measuring class achievement in General Science the Scale Forms are really very reliable, as is indicated by an average P. E. of medians of .9 and with close agreement of medians. Explanation of the difference of the medians on S-2 and T-2 is found in the case of School A to be due to the fact that this school offers an exceptionally fine course in Biology which is elected by most pupils and therefore omits from its General Science course as much biological material as possible. Because the items on Biology are not equally distributed in the Groups I, II, and III, failure on the Biology items in Group III where they are of most value had a tendency to lower the scores in Scale Form T-2 for this group of pupils.

E. CORRELATION WITH INTELLIGENCE TEST SCORES.

Correlation of General Science achievement scores on Scale Forms S-2 and T-2 with the intelligence test scores was computed for two groups of pupils. In both groups the correlation coefficient between intelligence test scores and General Science Scale scores was high. For 90 cases from Central High School, all of whom had taken General Science one year previous, the Pearson coefficient of correlation between General Science Scale scores and mental age in months from mental test scores (Haggerty Delta 2*) was .741, P. E. .03. For 81 cases a similar coefficient was .727, P. E. .035. For the University High School group of 50 cases the coefficient of correlation between mental test scores (Miller Mental Ability Test,† Form A.) and the scores on the General Science Scale

* M. E. Haggerty, University of Minnesota. World Book Company.

† W. S. Miller, University of Minnesota. World Book Company.

Form S-2 was .603, P. E. .06. For the same mental test scores and the General Science Scale Form T-2, r was .745, P. E. of .05. For the same mental test scores and the average of the General Science Scale scores for Forms S-2 and T-2, a was .633, P. E. of .057.

F. CORRELATION BETWEEN GENERAL SCIENCE MARKS AND SCALE SCORES.

To compute the relationship between General Science Scale scores and the marks that the pupils received in General Science, data were used from three schools. For School A, the Central High School in Minneapolis, data were available giving marks received in General Science a year ago by 90 pupils and also Scale scores in Form S-2 made April 6th, 1923.* These data gave a correlation of .50 (.496), P. E. .05. School B, Stillwater High School, gave the Scales S-2 and T-2 April 18th, 1923 to pupils who had taken General Science for about thirty weeks. By using an average of the monthly marks given by teachers for achievement in General Science, the following results were obtained.

	S-2	T-2	Average S-2 & T-2	Marks†
Number cases	140	140	140	140
Median	92	86	88	85
Sigma	6.1	4.1	4.5	5.7

r equals .72 P. E. .03, between Form S-2 scores and marks.
r equals .70 P. E. .03. between Form T-2 scores and marks.
r equals .74 P. E. .03, between Average of Form S-2 & T-2 scores and marks.

School C, the University High School, had 58 pupils in two groups, all of whom had taken General Science from September until April 20th. Final marks were available for two complete quarters and were evaluated on the basis "A" equals 6, "B" equals 5, "C+" equals 4, "C" equals 3, "C—" equals 2, "D" equals 1, and "F" equals O. Results follow.

Group 1	S-2	T-2	Average S-2 & T-2	Marks
Number cases	24	24	24	24
Median	87	87	87	8
Sigma	5.8	4.7	5.0	2.7

r equals .73 P. E. .06 for Form S-2 scores and marks.
r equals .64 P. E. .08 for Form T-2 scores and marks.
r equals .75 P. E. .06 for Average of Forms S-2 & T-2 scores and marks.

* Data furnished by J. E. Bohan (unpublished thesis).

† These marks were in percents, not letters.

Group II	S-2	T-2	Average S-2 & T-2	Marks
Number cases	34	34	34	34
Median	84	82	82.5	6.0
Sigma	5.8	4.0	4.6	2.8

r equals .71 P. E. .06 for Form S-2 scores and marks.
r equals .67 P. E. .07 for Form T-2 scores and marks.
r equals .82 P. E. .04 for Average of Forms S-2 & T-2 scores and marks.

In view of comparison of the above data with data previously given for the original 300 item General Science test, it is believed that the General Science Scale Forms R-1, S-2 and T-2 are even more reliable than was the original 300 item General Science test. Besides being more reliable, a Form of the Scale can be done by pupils of average capacity in twelve minutes, whereas the original test took one hour. The time required for scoring has been reduced to a minimum. The probable error of a measurement or estimation has been reduced from 10 points on the original test to 2 points on the 60 item Scale Forms by the elimination of unreliable items from the Scale. This reduction of the P. E. of estimation was effected without a corresponding reduction of group score medians, hence the reduction of P. E. from 10 points to 2 points is indication of greater reliability.

Scale Forms S-2 and T-2 are of equal difficulty and are so constructed that a score of 80 is the median achievement for 9th grade pupils who have taken General Science one year. This was established on the basis of the achievements of 1760 pupils. Scale Form R-1 is one P. E. or 10 points easier than Scale Forms S-2 and T-2. Therefore the median achievement for 9th grade pupils who have taken General Science one year is 90. Because of the known difficulty of each Form, the three forms may be used interchangeably to check up class progress in General Science from term to term, or they may be combined to secure still more accurate measurements of class or pupil achievements in General Science.

CHAPTER VIII

COMPARTIVE STUDY OF ACHIEVEMENT IN GENERAL SCIENCE.

In Chapter VII, under "B", data were presented which showed that, based on approximately 500 papers in five groups of 100 each, in which the original 300 item tests were rescored on the basis of one of the Scale Forms, the coefficients of correlation between distributions of test and Scale scores ranged

from .81 to .93 with a mean of .882. This would indicate that where distributions were used, distributions of either test or Scale scores would give approximately the same results, and that any statement made on the basis of test comparisons would have approximately the same justification on the basis of Scale comparison, as indicated by the coefficient of correlation of .882. In "C", however, when grade medians on test and grade medians on Scale Form S-2 were correlated, they gave a correlation coefficient of over .99. These correlations mean that any comparison made on the basis of the test would, with reference to an individual case, receive only as much justification by the Scale, or vice versa, as is indicated by a mean positive coefficient of correlation of .882. Any group comparison, however, made on the basis of a median of test scores, would receive practically identical justification on the basis of a median of Scale scores, or vice versa, as is indicated by a coefficient of correlation of .99 plus. Inasmuch as re-scoring approximately 9,000 300-item tests on the basis of the Scale would be a laborious, time-consuming process, and inasmuch as comparisons between the General Science test and other criteria were only slightly inferior to those of the Scale and the same criteria, and inasmuch as most of the comparisons are to be group comparisons, it was decided to base the study of achievement on the scores for the 300 item test which had already been made available. In other words, the development of the Scale Forms was necessary in order to prove that the original test was sufficiently accurate for measuring group achievement. The Scale Forms are a good check on the test medians. Since, however, for group comparisons the test medians give the same results as the scale medians and the test results were already at hand, the Scale results need not for economy's sake be used for this part of the study.

The following paragraphs are discussions of some of the comparative studies which have been made of the achievement in General Science as indicated by the 300 item test. If these studies were to be repeated it would be advisable to use one or more of the Scale Forms to secure data on pupils' General Science achievement because being now available the scales are much more economical of time and effort than was the test, but since the test data were already at hand they were used.

A. COMPARISON OF GROUP ACHIEVEMENT IN INDIVIDUAL SCHOOLS.

To facilitate the treatment and to increase the accuracy of data, results on each group were kept separately for each school. That is, all the data for the —8G were not only kept separately but were also subdivided according to schools from which they came. Thus it was possible to locate the results for —8G for School A, B, or K at will. Furthermore, since each of the administrators of the twenty-two schools co-operating in this study desired to have data on the achievement for his school compared with the rest, it was a matter of compilation of individual group results to formulate in tabular form the data by schools.

These data were on the first 221 items, which enabled the inclusion of practically 9,000 cases. To have compared achievement on 300 items would have allowed the use of about two-thirds of the data or about 6,000 cases. Data in Chapter V show that 300 item results on the General Science test and 221 item results on the same test agree to the extent of giving for a large number of the cases a product-moment correlation of .98 between the two. Therefore the comparative results by schools are as accurate for the 221 item test as they would have been had 300 items been used. They are in fact more accurate in the case of these data because of the additional 3,000 cases, the use of which was made possible by including the first 221 items of the test only.

These 9,000 cases included about 90% of all papers submitted. The 10% which had been eliminated were not used because (a) the pupils did not do as much as three pages in the original test, presumably because insufficient time was allowed for the test, (b) pupils had omitted necessary information such as their name, grade in school, and sciences taken, and (c) pupils (a small number) had misunderstood directions and in one way or another rendered their papers valueless.

With reference to the first reason given for elimination, in an examination of time taken for the test and the score obtained, the writer found that there was no relationship between time and success in the test. Four hundred and forty cases, over as wide a range of test scores as possible, were studied.

The wide range of scores selected gave excellent conditions for securing a high coefficient of correlation. These data, however, gave a product-moment coefficient of correlation of .09 with P. E. of .03 between time in minutes and score achieved. This result is easily explained by the fact that the directions for giving the test stated that no time limit was to be used. Directions of this kind would naturally cause pupils to work at comfortable rates rather than at maximum speed.

Examination of the test data for the different schools shows that schools differ quite markedly in their achievements on this General Science test. The fact that a course in General Science was previously taken gives the obvious results in all cases, namely, higher scores for pupils of any grade who have taken General Science than for pupils of the same grade in the same school who have not taken General Science. With regard to the latter result, some data will be presented later regarding the selective influence of General Science where the subject is elective. With regard to school achievements, the difference is in part at least due to differences in native ability and in part to the kinds of courses which are offered in the different schools. If the latter statement is really true, one of the valuable results of this study is to make available a device for measuring achievement in General Science, the use of which would be one of the first requisites in a study of the achievements in various courses in General Science.

B. OVERLAPPING.

It was possible to compute the degree with which the achievements of one of the grades studied was similar to the achievement of the grades above and below it. That there is an overlapping of the distributions of scores for the different grades is obvious from these data.

Inasmuch as the test results were secured on the pupils' responses to the 300 items, and also on the first 221 items of the test, two sets of data were available. Table IV *(Distribution of Scores of 8970 Cases on the First 221 Items of the General Science Test)* shows how some pupils in practically all grades made identical scores in spite of a gradual increase in median scores. Table V *(Percentile Scores on the First 221 Items Made by 8970 Cases Computed from Table IV)*

makes the overlapping of scores more obvious because it makes it possible to compare the scores of different portion *(percentiles)* of the different "groups." Table VI *(Distribution of Scores of 5980 Cases on the 300 Items of the General Science Test)* and Table VII *(Percentile Scores on 300 Items Made by 5980 Cases)* computed from Table VI show similar data on the basis of the 300 item test. Figure III *(Distributions of the General Science Test Scores for 300 Items)* is a graphic representation of the data found in Table VI. The gradual shifting of the median line to the right with the overlapping of surfaces needs no explanation. Figure IV *(Percentile Distribution of Scores Made on 300 Item Test by Different Groups of Pupils)* illustrates the data of Table VII.

TABLE IV

Distribution of Scores of 8970 Cases on First 221 Items of the General Science Test

SCORE	—8G	—8B	+8G	+8B	—9G	—9B	+9G	+9B	—10G	—10B	+10G	+10B
20– 24	1	..	..	..	..	..	..	..	..	..	..	..
25– 29	..	..	..	..	..	..	..	..	..	..	..	..
30– 34	1	..	..	..	..	..	..	..	..	..	..	..
35– 39	2	2	1	..	1	..	..	..	..	..	..	..
40– 44	1	4	..	..	..	..	..	..	2	..	..	..
45– 49	6	1	..	..	2	2	..	1	2	..	..	..
50– 54	8	5	..	..	2	..	..	..	3	..	..	1
55– 59	13	11	..	..	12	7	1	3	8	2	..	..
60– 64	24	17	1	1	13	4	1	1	6	3	..	2
65– 69	44	28	1	..	36	10	4	5	17	3	1	1
70– 74	52	25	1	1	43	13	6	10	34	11	2	3
75– 79	73	35	1	1	85	28	10	10	46	16	5	5
80– 84	84	40	5	3	87	38	20	17	66	25	13	8
85– 89	85	58	9	2	117	42	18	18	78	24	16	12
90– 94	74	56	6	1	100	44	44	35	94	36	20	16
95– 99	44	63	2	5	99	37	61	27	92	26	32	30
100–104	40	42	5	7	57	50	35	49	78	45	53	22
105–109	25	46	3	2	60	42	58	36	72	45	42	27
110–114	14	23	6	7	33	32	59	57	57	37	62	36
115–119	8	28	5	4	28	22	66	52	32	43	56	40
120–124	5	14	2	4	16	18	45	35	36	29	36	39
125–129	2	7	..	4	13	15	24	43	20	21	37	40
130–134	2	2	1	3	5	11	34	37	10	7	20	32
135–139	..	3	..	3	4	5	13	43	5	12	10	30
140–144	..	..	..	2	1	6	13	35	1	9	15	20
145–149	..	2	..	..	..	2	7	16	2	8	8	18
150–154	..	1	..	1	1	3	7	17	..	7	3	19
155–159	..	2	..	..	..	..	2	11	1	5	2	13
160–164	..	..	..	..	..	..	3	7	..	1	1	11
165–169	..	..	..	..	..	1	1	1	..	1	1	5
170–174	..	..	..	..	..	1	..	1	..	..	..	6
175–179	..	1	..	..	..	..	..	1	1	..	..	2
180–184	..	..	..	..	..	..	..	..	..	..	..	2
185–189	..	..	..	..	..	..	..	..	..	..	..	..
190–194	..	..	..	..	..	..	..	1	..	..	..	1
195–199	..	..	..	..	..	..	..	..	..	..	..	..
200–	..	..	..	..	..	..	..	..	..	..	..	..
Total No.	608	520	49	51	815	433	532	568	763	416	435	441

TABLE IV (*continued*)

Distribution of Scores of 8970 Cases on First 221 Items of the General Science Test

SCORE	−11G	−11B	+11G	+11B	−12G	−12B	+12G	+12B	UNIVERSITY I	II	III	IV	T.C.
20– 24	..	..	..	..	..	..	..	..	..	..	..	..	..
25– 29	..	..	..	..	..	..	..	..	..	..	..	..	..
30– 34	..	..	..	..	..	..	..	..	..	..	..	..	..
35– 39	..	..	1	..	..	..	..	..	..	..	..	..	..
40– 44	1	..	..	..	1	..	..	..	..	..	..	..	..
45– 49	1	1	..	1	..	..	..	..	..	..	..	..	..
50– 54	2	..	..	..	2	..	..	..	..	..	..	..	..
55– 59	6	1	2	..	..	..	..	..	..	..	..	..	..
60– 64	2	..	..	1	3	..	1	..	..	..	..	..	..
65– 69	8	1	2	..	2	1	1	..	..	..	..	..	..
70– 74	14	2	5	..	10	1	..	..	..	..	..	..	..
75– 79	20	2	1	..	10	1	4	..	..	..	..	..	..
80– 84	26	10	9	4	12	..	8	..	..	..	..	..	..
85– 89	32	9	15	2	15	2	6	..	..	..	..	..	..
90– 94	58	12	17	3	29	4	11	2	..	..	..	..	2
95– 99	57	14	21	5	34	8	13	2	..	..	..	..	..
100–104	62	17	21	8	40	10	21	3	..	..	..	..	3
105–109	59	25	46	12	41	10	27	3	..	1	..	..	2
110–114	48	37	37	21	43	17	26	5	..	..	..	..	4
115–119	48	23	34	22	53	25	22	8	1	2	..	..	4
120–124	44	36	39	22	36	23	25	9	1	3	1	..	4
125–129	38	24	25	19	33	16	35	20	..	5	..	..	..
130–134	24	35	26	27	31	18	31	25	1	2	1	..	7
135–139	23	34	18	24	24	24	23	24	2	9	2	..	..
140–144	9	23	10	31	16	31	19	26	4	15	2	..	..
145–149	6	19	6	27	20	30	17	18	1	11	1	1	2
150–154	4	16	7	20	12	25	17	11	2	23	3	2	2
155–159	4	11	1	16	5	26	6	17	1	22	4	..	2
160–164	1	8	4	15	2	7	4	19	3	32	10	4	..
165–169	3	4	2	15	..	9	..	15	4	34	4	1	..
170–174	..	2	1	2	2	3	2	6	4	23	6	2	..
175–179	..	..	1	6	2	5	2	5	5	29	7	4	..
180–184	..	..	..	3	1	4	2	6	3	17	2	2	..
185–189	..	..	..	2	..	..	..	2	..	12	3	1	..
190–194	..	..	..	..	..	..	..	..	..	6	..	3	..
195–199	..	..	..	..	..	..	..	..	..	1	..	1	..
200–	..	..	..	..	..	..	..	..	..	1	..	..	..
Total No.	600	366	351	309	479	300	323	226	32	248	46	21	32

TABLE V

Percentile Scores on First 221 Items Made by 8970 Cases

Group	Percentile: No. cases	0	1	SCORES 10	20	25	30	40
—8 Girls	608	20	47	65	71	74	77	81
—9 "	815	35	56	72	77	80	83	86
—10 "	763	40	55	75	82	85	87	92
—11 "	600	40	56	81	90	93	95	101
—12 "	479	40	63	87	96	100	103	109
+8 Girls	49	35	..	79	84	86	87	91
+9 "	532	55	69	88	95	97	99	106
+10 "	435	65	76	91	99	101	103	108
+11 "	351	35	67	90	99	102	106	110
+12 "	323	60	77	95	104	107	110	117
—8 Boys	520	35	43	66	75	79	82	88
—9 "	433	45	56	76	82	85	88	93
—10 "	416	55	64	81	89	93	95	102
—11 "	366	45	72	94	105	109	112	118
—12 "	300	65	84	106	116	119	122	130
+8 Boys	51	60	..	82	96	98	100	104
+9 "	568	45	65	87	97	101	104	111
+10 "	441	50	70	92	102	107	110	116
+11 "	309	45	82	107	116	119	123	130
+12 "	226	90	97	119	128	130	134	137
University 1	32	115	..	135	142	143	147	157
" 2	248	105	119	140	150	153	155	161
" 3	46	120	..	142	154	157	159	162
" 4	21	145	..	154	162	163	164	171
Teachers Coll.	32	90	..	103	108	110	113	117
Total No.	8970							

TABLE V (*continued*) . .

Percentile Scores on First 221 Items Made by 8970 Cases

Percentiles: *Group*	SCORES 50	60	70	75	80	90	99	100
—8 Girls	84	88	92	94	97	104	123	134
—9 "	90	94	98	100	104	112	132	154
—10 "	96	100	105	108	111	119	137	179
—11 "	105	111	117	120	124	152	157	169
—12 "	114	119	125	129	133	143	165	184
+8 Girls	95	102	107	111	113	118	..	134
+9 "	111	115	119	122	124	133	155	169
+10 "	112	116	120	123	126	134	154	169
+11 "	114	119	124	128	130	138	165	179
+12 "	124	129	134	137	141	150	175	184
—8 Boys	92	96	101	104	107	116	145	179
—9 "	98	103	108	111	114	125	150	174
—10 "	106	111	117	119	122	135	157	169
—11 "	124	130	135	138	141	151	167	174
—12 "	137	143	148	150	153	159	181	184
+8 Boys	111	116	122	125	128	136	..	154
+9 "	116	121	128	132	135	144	168	194
+10 "	122	127	134	137	141	153	175	194
+11 "	135	140	147	150	154	163	183	204
+12 "	142	147	155	158	161	168	184	189
University 1	162	168	172	174	176	179	..	184
" 2	164	169	173	175	177	183	194	204
" 3	164	169	173	175	176	180	..	189
" 4	175	177	180	182	185	191	..	199
Teachers Coll.	120	130	132	133	134	150	..	159

TABLE VI

Distribution of Scores of 5980 Cases on the 300 Items of the General Science Test

SCORE	—8G	—8B	—8G	—8B	—9G	—9B	—9G	—9B	—10G	—10B
20– 24	..	..	..	..	..	..	..	..	..	..
25– 29	1	..	..	..	1	..	..	..	..	..
30– 34	..	..	..	..	..	..	..	..	..	..
35– 39	..	..	..	..	..	..	..	..	..	..
40– 44	..	..	..	..	..	..	..	..	..	..
45– 49	1	..	..	..	..	..	..	..	..	..
50– 54	3	3	1	..	..	..	1	..	..	..
55– 59	2	1	..	..	..	1	..	..	..	..
60– 64	4	5	..	..	1	1	..	..	2	..
65– 69	5	5	..	..	4	..	..	..	1	..
70– 74	7	7	..	..	..	1	..	..	3	..
75– 79	6	9	..	..	2	3	..	2	1	..
80– 84	23	7	..	..	7	3	2	5	3	1
85– 89	24	10	1	..	9	3	2	3	3	2
90– 94	27	9	1	..	16	2	5	2	8	2
95– 99	26	16	1	3	13	6	4	9	8	1
100–104	33	21	1	..	29	9	4	3	13	5
105–109	46	21	1	2	33	9	10	10	21	4
110–114	48	19	2	1	24	19	13	4	27	6
115–119	49	25	4	..	38	16	18	13	46	14
120–124	39	25	2	4	49	17	18	16	29	17
125–129	44	33	5	1	50	28	20	16	41	30
130–134	25	39	5	1	41	28	28	11	46	11
135–139	14	26	3	4	34	18	24	19	46	18
140–144	23	23	1	3	26	16	33	27	42	19
145–149	24	32	3	3	26	19	33	20	38	24
150–154	7	19	1	2	29	19	34	22	33	18
155–159	4	11	4	5	12	15	31	29	21	21
160–164	3	16	5	1	12	12	32	24	19	20
165–169	4	8	2	4	7	9	31	26	18	20
170–174	4	4	..	3	6	9	22	21	10	10
175–179	2	3	1	4	7	6	15	23	11	14
180–184	2	3	..	5	1	13	15	29	8	8
185–189	..	..	..	1	3	3	13	17	4	4
190–194	..	..	..	1	1	3	6	18	2	7
195–199	..	..	..	1	..	5	6	22	2	6
200–204	..	..	..	..	1	1	7	6	4	2
205–209	..	..	..	..	..	3	3	8	1	3
210–214	..	..	..	..	..	1	3	10	..	5
215–219	..	..	..	..	..	..	3	6	..	3
220–224	..	..	..	..	..	..	..	4	2	..
225–229	..	..	..	..	..	..	..	3	..	2
230–234	..	..	..	..	..	1	..	..	..	1
235–239	..	..	..	..	..	1	1	..	..	..
240–244	..	..	..	..	..	..	..	2	..	..
245–249	..	..	..	..	..	..	..	..	..	..
250–254	..	..	..	..	..	..	..	..	..	..
255–259	..	..	..	..	..	..	..	..	..	..
260–264	..	..	..	..	..	..	..	..	..	..
Total No.	500	400	44	49	482	300	437	430	513	829

TABLE VI (*continued*)

Distribution of Scores of 5980 Cases on the 300 Items of the General Science Test

SCORE	—10G	—10B	—11G	—11G	—11B	—11B	—12G	—12G	—12B	—12B
20– 24	..	..	..	..	..	..	..	..	..	..
25– 29	..	..	..	..	..	..	..	..	..	..
30– 34	..	..	..	..	..	..	..	..	..	..
35– 39	..	..	..	..	..	..	..	..	..	..
40– 44	..	..	..	..	..	..	..	..	..	..
45– 49	..	..	1	..	..	..	..	..	..	..
50– 54	..	..	..	..	..	1	..	..	..	..
60– 64	..	..	..	1	..	..	..	..	..	..
65– 69	..	2	..	..	1	..	..	..	..	..
70– 74	..	..	1	..	1	..	..	..	..	..
75– 79	..	..	1	1	..	..	..	..	..	..
80– 84	..	1	2	..	..	..	1	..	..	..
85– 89	..	..	2	..	1	..	..	..	..	..
90– 94	..	..	1	..	..	..	..	..	..	..
95– 99	..	1	3	..	..	..	3	1	..	..
100–104	2	..	6	..	..	..	3	1	1	1
105–109	3	1	11	2	3	..	3	2	1	..
110–114	3	3	13	5	3	1	4	..	..	..
115–119	2	4	16	8	3	..	7	5	..	..
120–124	13	6	15	3	5	1	8	2	1	..
125–129	8	6	19	8	2	1	8	4	3	..
130–134	12	10	28	7	10	1	12	3	..	1
135–139	23	13	36	8	8	2	17	6	6	3
140–144	14	10	29	8	14	1	17	8	3	..
145–149	16	14	35	16	8	5	23	11	2	3
150–154	19	10	30	17	10	6	25	4	7	..
155–159	29	14	29	17	14	6	30	7	8	5
160–164	22	14	34	17	21	2	24	6	9	6
165–169	26	18	24	12	17	9	26	8	13	7
170–174	12	15	30	9	21	8	19	19	15	5
175–179	12	12	22	11	19	7	27	22	13	10
180–184	10	18	12	13	16	15	17	14	9	15
185–189	9	8	15	5	17	8	13	16	9	12
190–194	8	16	4	8	15	13	12	11	17	14
195–199	9	13	10	5	11	8	11	10	24	8
200–204	3	5	5	5	9	8	11	9	13	8
205–209	2	4	3	2	9	7	15	6	9	8
210–214	2	6	1	2	8	7	5	7	16	11
215–219	1	4	2	3	6	7	..	3	9	4
220–224	1	5	..	3	6	7	2	1	4	3
225–229	1	3	..	1	3	3	2	..	9	8
230–234	..	4	..	1	2	3	..	..	2	3
235–239	..	..	..	..	..	..	2	4	1	1
240–244	..	..	..	..	..	3	..	..	2	4
245–249	..	..	..	..	..	2	..	2	3	..
250–254	..	1	..	..	..	1	..	..	..	..
255–259	..	1	..	..	..	..	..	..	..	1
260–264	..	..	..	..	..	..	..	..	1	..
Total No.	261	242	440	197	263	143	347	192	210	141

Table VII

Percentile Scores on 300 Items Made by 6053 Cases

Group	*Percentile:* *No. cases*	SCORES 0	1	10	20	25	30	40
—8 Girls	500	29	54	84	94	99	103	109
—9 "	482	23	67	98	107	110	115	121
—10 "	513	60	72	107	116	119	122	129
—11 "	440	45	84	115	129	133	136	143
—12 "	347	84	99	129	139	145	148	156
+8 Girls	44	54	69	104	117	119	122	128
+9 "	437	50	89	113	128	132	137	144
+10 "	261	102	106	127	138	139	144	151
+11 "	197	63	104	123	138	143	147	151
+12 "	192	99	104	134	147	152	159	171
—8 Boys	400	50	59	87	101	107	111	120
—9 "	300	58	74	105	116	121	124	130
—10 "	289	84	89	116	126	130	136	143
—11 "	263	69	104	134	147	154	158	165
—12 "	210	104	120	152	165	168	173	181
+8 Boys	49	95	95	108	124	133	138	147
+9 "	430	75	78	117	131	138	142	152
+10 "	242	67	89	128	140	146	150	159
+11 "	143	54	110	151	166	170	172	183
+12 "	141	103	130	160	171	179	180	184
University 1	9	190	..	190	199	201	208	219
" 2	134	125	175	198	210	214	218	224
" 3	18	189	..	205	214	215	216	219
" 4	6	206	..	..	..	212	..	..

TABLE VII (*continued*)

Percentile Scores on 300 Items Made by 6053 Cases

Percentiles: *Group*	50	60	70	SCORES 75	80	90	99	100
—8 Girls	114	119	125	128	132	144	174	184
—9 "	126	131	137	142	146	155	184	202
—10 "	135	140	148	150	155	167	203	222
—11 "	150	157	164	168	172	183	207	217
—12 "	162	169	177	181	186	200	224	239
+ Girls	131	139	148	157	159	163	175	179
+9 "	150	157	163	166	171	184	214	236
+10 "	157	163	168	172	178	189	219	228
+11 "	158	165	174	178	183	197	224	231
+12 "	175	183	189	192	197	206	239	249
—8 Boys	127	133	139	145	147	157	178	184
—9 "	135	144	152	156	161	180	209	235
—10 "	150	157	165	167	173	190	219	233
—11 "	172	178	187	191	197	210	227	230
—12 "	190	196	203	207	212	220	246	262
+8 Boys	155	162	170	174	176	183	195	195
+9 "	162	169	179	183	187	199	225	244
+10 "	168	176	184	190	194	213	234	257
+11 "	188	194	203	207	213	224	247	251
+12 "	190	196	204	209	213	228	244	255
University 1	228	235	236	237	238	242	..	246
" 2	228	232	239	241	244	249	264	274
" 3	229	238	241	242	244	247	..	262
" 4	236	..	..	259	..	..	..	264

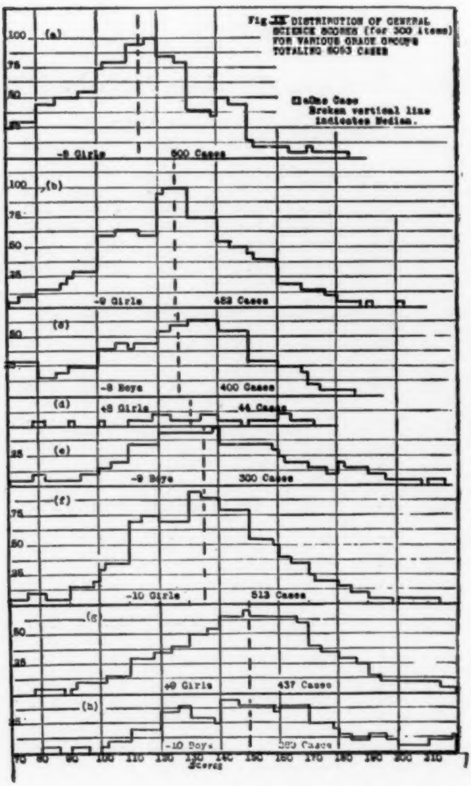


Fig. III DISTRIBUTION OF GENERAL SCIENCE SCORES (for 300 items) FOR VARIOUS GRADE GROUPS
= One Case
Broken vertical line indicates Median.
(a) -8 Girls 500 Cases
(b) -9 Girls 482 Cases
(c) -8 Boys 400 Cases
(d) +8 Girls 44 Cases
(e) -9 Boys 300 Cases
(f) -10 Girls 513 Cases
(g) +9 Girls 437 Cases
(h) -10 Boys 380 Cases
100
75
50
25
70 80 90 100 110 120 130 140 150 160 170 180 190 200 210
Score

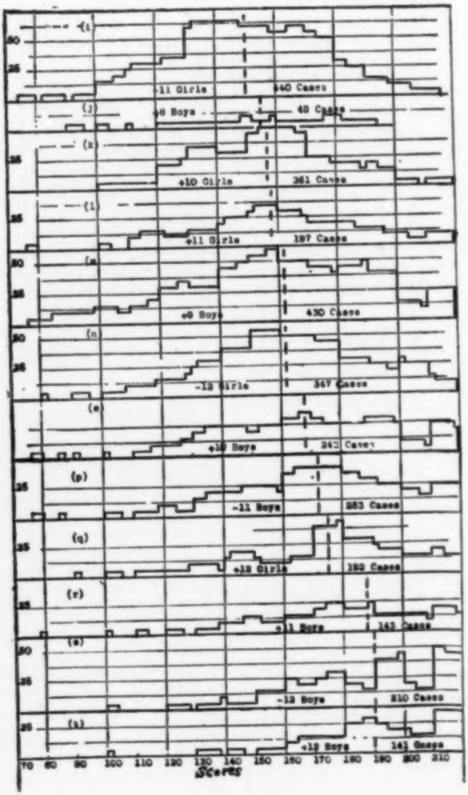

(i)
+11 Girls
440 Cases
(j)
49 Cases
(k)
+10 Girls
361 Cases
(l)
+11 Girls
197 Cases
430 Cases
(n)
-12 Girls
347 Cases
(p)
-11 Boys
253 Cases
(q)
(r)
(s)
-12 Boys
210 Cases
(t)
+12 Boys
70 80 90 100 110 120 130 140 150 160 170 180 190 200 210
Scores

FIGURE IV (a)

PERCENTILE DISTRIBUTION OF SCORES MADE ON 300 ITEM TEST BY GIRLS WHO HAD NOT TAKEN GENERAL SCIENCE.

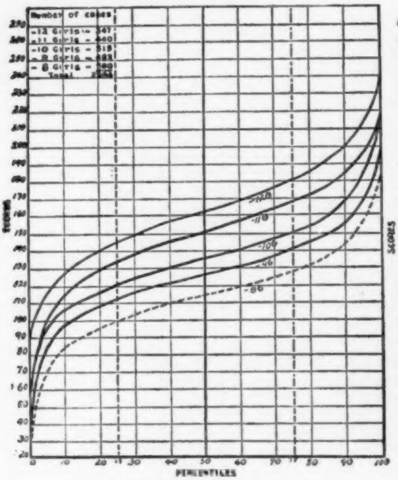


FIGURE IV (b)

PERCENTILE DISTRIBUTION OF SCORES MADE ON 300 ITEMS BY GIRLS WHO HAD TAKEN GENERAL SCIENCE

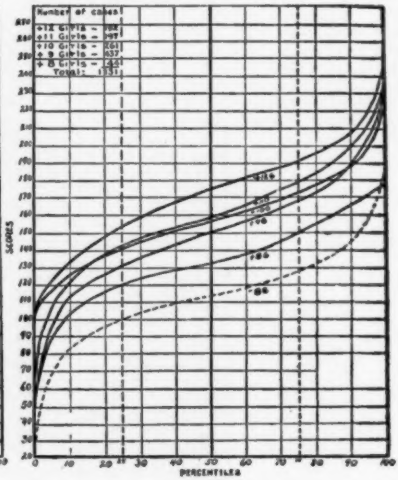


FIGURE IV (c)

PERCENTILE DISTRIBUTION OF SCORES MADE BY BOYS WHO HAD NOT STUDIED GENERAL SCIENCE, ON 300 ITEM TEST.

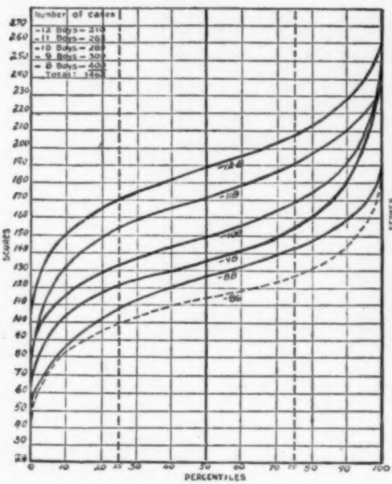


FIGURE IV (d)

PERCENTILE DISTRIBUTION OF SCORES MADE ON 300 ITEMS BY BOYS WHO HAD TAKEN GENERAL SCIENCE

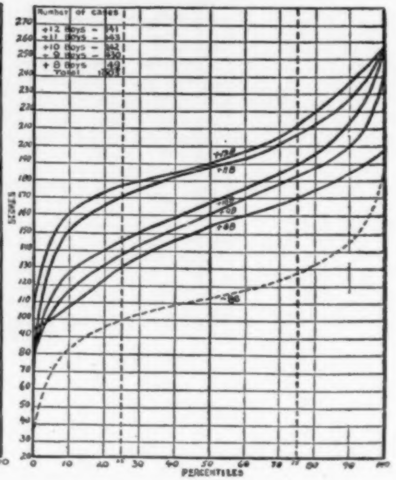
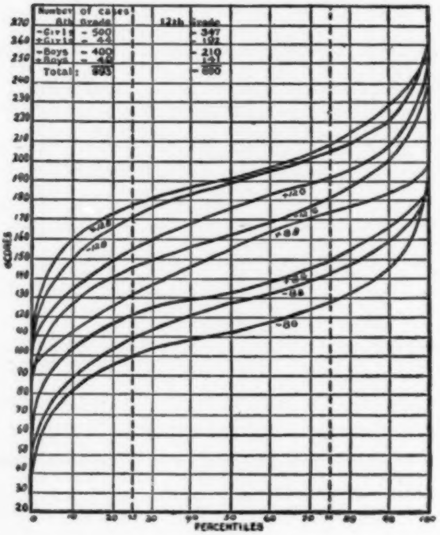


FIGURE IV (e)

DISTRIBUTION OF SCORES MADE ON 300 ITEM TEST BY EIGHTH AND TWELFTH GRADE PUPILS



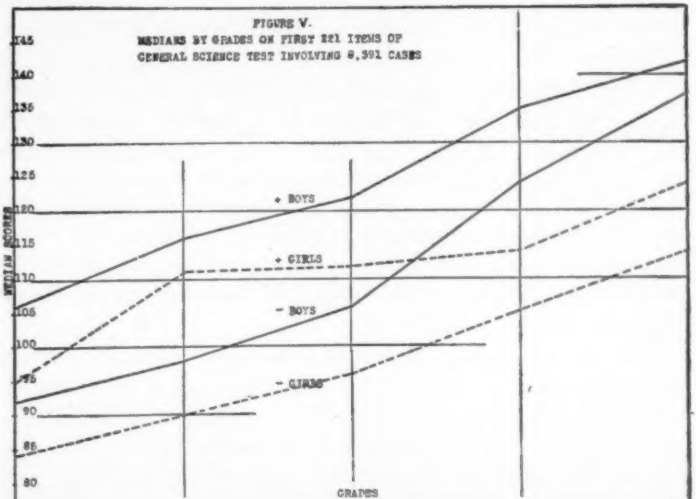


FIGURE V.
MEDIANS BY GRADES ON FIRST 221 ITEMS OF GENERAL SCIENCE TEST INVOLVING 8,391 CASES

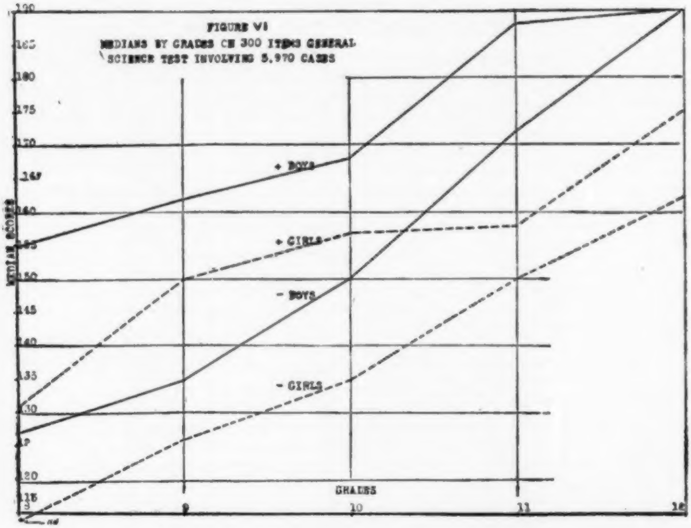


FIGURE VI
MEDIANS BY GRADES ON 300 ITEMS GENERAL
SCIENCE TEST INVOLVING 5,970 CASES

A glance at either table of distributions or of percentile distributions for scores on 300 items or on 221 items, will show that the medians varied from grade to grade and from group to group. To facilitate comparisons the medians for each grade and group on both the 300 item and the 221 item distributions, the medians have been plotted in Figures V *(Medians by Grades on First 221 Items of General Science Test Involving 8,591 Cases)* and VI *(Medians by Grades on 300 Items General Science Test Involving 5,970 Cases).*

Naturally at least three questions might be asked relative to the data and figures presented, namely, (1) How reliable are the medians presented? (2) Are the groups of equal variability? (3) Are the differences noted between the medians of the different groups real, significant differences or are they the result of chance?

The computation of the answers to these questions are too extended to be presented in detail, therefore a summary of each will be presented. To find any particular detail will entail small effort on the part of the reader.

(1) The medians for both the 221 and the 300 item distributions are reliable. For the 300 item distribution the

P. E.'s of the medians computed by the formula

$$\text{P. E. of median} = \frac{1\frac{1}{4}\text{ P. E. of Distribution''}}{\sqrt{N}}$$

range from .8 to 1.8 points. For the 221 item distribution the P. E. of the median range from .4 to 1.0. In other words, were these distributions extended infinitely, the chances are even that in the least reliable group the median (50 percentile) would not vary by more than 1.8 points from that given in Table VII, and 1.0 points from that given in Table V. The quartile deviations for the twenty groups are likewise very constant, varying from 14½ to 22½ in Table VII, and from 10 to 15½ in Table V.

(2) The variability of the groups decreases in the upper years. Seniors are less variable in their achievement on the General Science test, especially if they have taken General Science, than are 8th grade pupils who have not taken General Science. A course in General Science tends to cut down the variability in the test. Using the formula,

$$\text{Variability coefficient} = \frac{\text{100 Quartile Dev.}}{\text{Median}}$$

the coefficient of Variabiliay varies in the 300 item distributions from 12. 7 for —8G, the most variable, to 8.0 for +12B, the least variable group. In the 221 item distributions, the variability coefficient varies from 12.0 for the —8G, to 10.0 for the +12B.

(3) The difference between median achievements of the grades of any one group, as —Girls or +Boys, are all significant and real differences. Likewise the sex differences are real differences. In most cases the differences between medians are from two to four times as large as they have to be in order to be significant and real differences. McCall gives formulae for finding the reliability of a Difference.* Namely, Sigma of Difference = $\sqrt{\text{Sigma } 1^2 \text{ \& Sigma } 2^2}$, and

$$\text{Experimental Coefficient} = \frac{2.78 \times \text{Sigma of Difference}}{\text{Difference}}$$

When, by the use of these formulæ, the experimental coefficient equals 1, McCall states that the difference is real, that is, cannot be considered the result of chance.

* McCall, W. A. "How to Measure in Education," pp. 398-407. The Macmillan Co., N. Y., 1922.

Since the computation and presentation of all the differences would be lengthy, the writer proposes to use these formulæ to compute a difference that will just give an experimental coefficient of 1. Then all differences which exceed the amount necessary just to produce an experimental coefficient of 1 are large enough to be beyond doubt real differences and not the products of chance distributions.

In the answer to question (1) is found data which indicates that for the medians on 300 item distributions, the P. E.s of the medians ranged from .8 to 1.8 and for the medians of the 221 distributions the P. E.s ranged from .4 to 1. By taking the smallest and largest P. E. of median in each set of data we find that the sigma of differences for the 300 item distributions range from 1.8 to 3.8 and for the 221 item distributions range from .8 to 2.2. Using McCall's second formula so as to have the experimental coefficient equal 1—for the minimum sigma difference of the 300 item distribution—this $1 = \frac{\text{Difference}}{2.78 \times 1.8}$, then Difference equals 5.2. That is, for the distribution having the lowest P. E. of the median, namely .8 and a sigma difference of 1.8, a Difference of 5.2 gives an experimental coefficient of 1. This coefficient indicates with practical certainty that the difference is not a result of chance distributions in two series. Repeating the above process for Sigma Differences 3.8, .8, and 2.2, it is found that to secure an experimental coefficient of 1 for all the 300 item distribution differences of medians, the differences must range from 5.2 to 10.5. For the 221 item distribution differences of medians, the differences must range between 2.2 and 6.1.

Examination of the actual differences of medians (see Tables V & VII) shows, as stated before, that the differences are real differences and not due to chance even in the case of the four groups in the same grade. When the differences found between medians of the same group, two or more grades removed, are considered, the experimental coefficient becomes as much as 6 times as large as it need be to eliminate all chance of accidental distributions causing the differences.

From the above examination it is evident that though the differences between grades are not due to chance they are small, and that in each grade there is a certain appreciable

percent of pupils who fall below the median of the grade just below, and also an appreciable percent of pupils who fall above the median of the grade next higher. Perhaps the most striking illustration of overlapping is to be found in Figure IV (e)—8th and 12th grade pupils. This figure shows that from 4% to 40 % of the 8th grade pupils' scores were above the median of the —12 Girls, 2 to 20% of the 8th grade pupils' scores were above the median for the +12 Girls, while 3% of the +8 Boys were above the median for the —12 Boys. In fact it was impossible to find any grade group which does not overlap considerably with each of the other grade groups. This illustration is of the extreme case, for it involved the 8th and 12th grades, the widest range of grades. For two adjacent grades the overlapping is even greater.

C. *Numbers of Sciences.*

Since there are significant differences among the achievements of the different grade groups, all of which are in favor of the higher grades and also in favor of the pupils who had studied General Science, the question arose as to the probable causes of greater achievement, other than the fact that the pupil had taken General Science. This was an important question inasmuch as the figures and data show a constant growth of achievement whether pupils take General Science or not, the only difference being in the relative amounts of the growth.

It is important to note that the median of the +12 Girls is only 13 points or a little less than 1 P. E. of the distribution above the median of the +12 Girls [see Table VII, or Figure IV(e)]. Likewise note may be made that the median of the +12 Boys was identical with the median of the —12 Boys. The latter condition, however, was due largely to chance, as it was not found in the 221 item distributions and was the only case of its kind. In the Tables of the 221 item distribution (Table V), the median of the +12 Girls is 10 points or slightly less than 1 P. E. of distribution above the median of the —12 Girls, and the median of the +12 Boys is only 5 points of ½P. E. of distribution above the median of the —12 Boys. Further, the amount of increase of achievement as noted by medians is 30 points between —8 Girls and —12 Girls, and 40 points between —8 Girls and +12 Girls. For the boys the difference between median of

—8 Boys and —12 Boys is 45 points, and between —8 Boys and +12 Boys 50 points, when based on the distribution Table V. Similar data for 300 item distribution Table VII show that the difference between the medians of —8 Girls and —12 Girls is 48 points, between —8 Girls and +12 Girls is 61 points, between —8 Boys and —12 Boys is 63 points, and between —8 Boys and +12 Boys is 63 points.

The decided superiority of achievement on the part of pupils who had not taken General Science and have reached the 12th grade, over the respective medians of their 8th grades has at least two explanations.

(1) Sciences other than General Science taken by the pupil have accounted for this growth.

(2) Elimination of the less capable pupils might account for an apparent growth. The latter explanation, however, is subject to two criticisms—(a) The correlation between scores and time of doing the test, which usually has a positive correlation with intelligence test scores, was practically zero, and (b) likewise the correlation between chronological age and scores was near zero. Both these correlations show that the less capable pupils were in the groups taking the test, at least in some numbers.

(To be concluded in the May number.)

A Trip Through The Sky

By MILDRED E. REEVE

Hathaway Braun School, Cleveland, Ohio

THIS fall a group of girls in the eighth grade had become very much interested in their Sky Neighbors and had greatly enjoyed looking through the telescope at the Case School Observatory. Therefore, when they were chosen to prepare a program for the morning exercises of the school, they voted immediately to represent in some way the activities of the heavens. The little play given below was the result of their efforts. It is needless to add that they found much amusement in working it up.

The costumes were very simple. We depended for the most part upon scarfs and cheesecloth. The witch had an old Hallowe'en costume and the sun a large circle of cardboard

covered with yellow which had been used in dramatics some time before. Sirius and Arcturus were draped in yellow cheesecloth, Mercury had black on one side and white on the other, and Venus was covered with veils. The other costumes were equally simple. Balloons were used for moons.

A TRIP THROUGH THE SKY

Witch *(strolling in):* After such strenuous exertion on Hallowe'en, I declare I feel that I must take a vacation—an educational one, I mean, for there's nothing like improving one's mind. And, as I know this old earth so well, I believe I shall visit the realms outside. So come to me, my honest steed *(goes over to her broom),* and let us go abroad. Mere humans could not leave this earth, but not even gravity can hold a witch down. *(She rides around.. Meanwhile the Sun enters.)* But what is this I feel? Such a strong heat! What is it? Oh, dear!

Sun: I am the sun, the chief of the solar system. No wonder you are frightened by my heat, for I have a temperature of 10,000° F. My rays extend for millions and millions of miles out into space and I give light to all my planets. In me all the minerals are found in a fiery state. In fact I am the greatest creature in the universe.

Sirius: Say not so, oh Sun, say not so. For I, Sirius, am far greater than are you. To be sure, you have a diameter of about 860,000 miles, but my mass is 3.4 times as large as yours. You travel through space at only twelve miles a second, while I speed along at seventeen miles a second. You give off great light, but my radiating power is forty-eight times the power of yours. Yes, I am the brightest sun in the universe.

Arcturus *(entering):* But not the largest, friend Sirius, not the largest. For I, Arcturus, in the constellation of Boötes, am the largest known sun. I have a diameter one hundred times that of the sun and I have 6000 times its light-giving power. I am so large that I am called a giant sun. But we are first magnitude stars. Let us hurry on and leave this small creature behind. Large as I am I must cover over 200 miles this next hour. *(Exit Sirius and Arcturus.)*

Sun: Jealous old cat stars. But I am sure they can have no such families as mine. Come hither, my children, and show our visitor your loveliness. *(Enter minor planets and*

Moon.) This is Mercury, my smallest one. Now, Mercury, tell us why you always look so queer.

MERCURY: I look so queer because I am always facing you, oh Sun. Never can I turn my face away. I go around you like this. *(Turns).* See! So that one side of me is always burning and the other is freezing. The only place I am comfortable is here *(pointing to her sides).* Otherwise, I am miserable. Then, too, I have no nice clouds to protect me from your fierce rays.

EARTH *(stepping forward):* Here, poor Mercury, take one of my glaciers.

MERCURY: Thank you, Earth.

WITCH: Poor Mercury, can nothing be done for you?

SUN: I'm sorry, Mercury, but that seems to be your place in the universe.

WITCH: But who is this beautiful and mysterious damsel?

VENUS: I am Venus, the second planet from the sun. I am mysterious because I am so covered with clouds that no one can see me. These same clouds make me beautiful, also, since they catch the sun's magnificent rays and reflect them, making me seem as beautiful as a star. That is why people call me the morning and evening "star." But I am not a star, only a planet, shining when the sun shines upon me. If he should turn away his strong rays, I should no longer shine, for such is the fate of a planet.

EARTH: Yes, that is so. That is the way it is with me, the Earth, and with the satellites also. When I get in the way between the sun and my moon, it cannot shine, and when it gets between the Sun and me, I cannot shine. We are helpless without the Sun, are we not, my little friend? *(Moon agrees.)* But *(turning to the Moon),* while we are having this discussion, tell me why it is that sometimes I can see a quarter of you, sometimes a half and again only a crescent. Why can I not see all of you all of the time?

MOON: You cannot see all of me all of the time because I don't turn my sunny side toward you very often. You see only half of me eve: shines, anyway, and when you see my shiny face you say the moon is full. When you see an edge, you exclaim, "Oh, there is the new moon! Make a wish quickly!" As if I could make any one's wish come true! This is the way I go. *(Revolves around the Earth making one rotation to a revolution).*

Earth: But where is the Lady in the Moon?

Moon: Such a joke! Such a joke! Could any lady live here, where there is no air? That picture which you call the Lady or the Man in the Moon is only the shadow of my mountains down onto the plains. But won't you please tell me why I must follow you around all the time? Why don't you go around me for a change?

Earth: That, my dear, is because you are so small that you cannot pull as hard as I can. One of my famous scholars, Sir Isaac Newton, told the truth when he said that all bodies attract all other bodies according to their size. But here is a neighbor of ours about whom I have always been curious. *(Turns to Mars)* Tell me, please, oh Mars, do you have inhabitants as I do, or do you not need to be troubled by them? I have always wished to know.

Mars *(laughing)*: That is the question which greatly troubles the old Earth. Am I inhabited? Are my black lines canals or only atmosphere? Where do my polar caps go in the spring? Is my air heavy enough for life? Indeed, I am getting quite vain, for your people have taken my picture scores of times this year. But we won't tell them our secrets, will we, moons? *(tossing her two moons, balloons, in the air)*.

Earth *(disconsolately)*: I wish I knew.

Planetoid *(entering hurriedly)*: I come to apologize, oh Sun, for the other 799 of us. The rest thought they should stay and continue to travel in our orbit lest some of the tiny ones be lost. We are the planetoids. Many thousands of years ago, a terrible thing happened to us when we were still whirling around. Our gravity failed us and was not strong enough to hold us together. We could not form a planet as others did, and now it is too late, too late. We shall always be separate.

Sun: Well, now that you have seen the smaller members of my family, let me show you the others who are larger but seem younger.

Mars: If those big fellows are coming, we would better go. *(They all go off)*.

Sun: Here is Jupiter, the largest of them all.

Witch: What is that queer belt he is wearing?

Jupiter: This is my cloud belt. And this is my famous red spot. Did you ever see me rotate? I like to whirl very

much and I usually go fast but my moons have to go with me and sometimes they seem heavy. *(He whirls off.)*

WITCH *(turning to Saturn)*: I suppose your belts are the same as Jupiters.

SATURN: *Those are my rings.* Be careful, because they are very light. In fact, they are only swarms of meteors. Evidently they were supposed to have made more moons, but as I already have nine, I don't need any more. Watch them as I rotate. *(Whirls off.)*

SUN: These are the last two of my family. I really know very little about them.

URANUS: I am Uranus, the next to the farthest from the sun.

NEPTUNE: And I am Neptune, the farthest of all. In fact, I am so far away that it takes me 165 years to go around the Sun. I was discovered in 1846 and as that is only 78 years ago, I have not yet half finished a trip. So I must be going or I shall never cover my years' stretch. *(Both go off.)*

SUN: I too must be on my way. What a time I have wasted here with you! Of course, we were glad to see you but you hinder us, so don't come again. What would the planets do if the sun should become tardy? *(Goes off.)*

WITCH: Aren't they interesting? Well, I daresay my Hallowe'en friends would all like to take such a trip, but they will never believe me when I tell them about it. I'll go tell them, anyway. *(Turns to the audience.)* Do you believe it? *(Runs off with her broom.)*

Modern dyestuffs can be just as fast and give just as beautiful colors as any used in past times, says the United States Department of Agriculture. It is sentiment chiefly that makes us cling to the idea that the natural dyes obtained from plants and animals are best. Many of them are lovely colors, it is true, and the time that has passed since the cloth was dipped in the dye-pot has in many cases mellowed the tones and made them even lovelier. Many of the so-called artificial dyes used now are exactly the same from the chemical standpoint as those from berries and bark and other natural sources. In some cases the new dyes are better than the old. The modern manufacturer of dyestuffs knows exactly what is in them, and for that reason is surer of results.

CHARLES EDWARD MUNROE

A Half Century In Chemical Education

A Chronological Record of the Scientific Contributions of Charles Edward Munroe.

By J. N. Taylor, George Washington University.

Much has been said and written of Charles E. Munroe and of his many sided scientific and literary activities. So many and so varied are they, that it is difficult, indeed, to catalog the activities of a scientist who, although a specialist, does not bring a specialized spirit to the study of his problems. Keeping the problem—whatever it may be—in perspective: noting relationships and discriminating differences; his specialization is servant to all science.

The marvelous output from the pen of one having a catholicity of interests and possessing a fund of scientific knowledge of unusually broad scope, must necessarily be of great value to teachers and students, and to all concerned with the progress of science. The presentation of his bibliography, however, without some reference to the man himself, would be incomplete.

Charles Edward Munroe was born at Cambridge, Massachusetts, on May 24, 1849, coming from a long line of sturdy New England ancestors, many of whom rendered important military service during the war of the Revolution. His schooling was obtained first in a private kindergarten and later in the public schools of his native city. On graduation from the Cambridge High School he matriculated at the Lawrence Scientific School of Harvard University, where he had as his master the foremost American chemist of his day, Professor Wolcott Gibbs, in whose researches he later served as assistant.

He was graduated from Harvard in 1871, receiving the S. B. degree, *summa cum laude*. In 1871 he was appointed Assistant in Chemistry, under Professor J. P. Cooke, who was head of the department. Professor Munroe was given full charge of the course in Quantitative Analysis for Seniors, which he carried on independently for three years. He also conducted a course in wet Assaying. In 1872-3 he established the course in Chemical Technology, and during the summers of 1873 and 1874 he conducted the first established Summer School in Chemistry, probably the first in the world. In that

School he gave instruction in General Chemistry, with illustrated lectures, together with qualitative and quantitative analysis.

In 1874 he was appointed Professor of Chemistry at the United States Naval Academy, holding that chair for twelve years, until in 1886 he was called to the Naval Torpedo Station at Newport, Rhode Island. From 1886 until 1892 he was engaged in chemical activities at the Torpedo Station and the Naval War College. From 1892 to 1917 he was head professor of chemistry at George Washington University; acting from 1892 to 1898 as dean of the Corcoran Scientific School, and from 1893 to 1917 as dean of the School of Graduate Studies, which he originated. Since 1917 he has been dean emeritus of the School of Graduate Studies and professor emeritus of chemistry of George Washington University. He received from George Washington University the degrees of Ph.D. and LL.D.

Professor Munroe's graduating thesis at Harvard was on analytical methods and apparatus, and throughout his career this topic has appealed to him. He has published many articles in this field and has devised many pieces of apparatus which have come into more or less general use, and all have been of value. Among them may perhaps be noted his Porous Cone, in the making of which he developed a new principle for the production of fine and uniform pores throughout a biscuit of plastic matter by incorporating within the plastic mass, before the matter was shaped and burned, a volatile substance, preferably ammonium chloride. This porous material was subsequently extensively used for biochemical filtrations in the Pasteur-Chamberland filter. In the development of the application of Porous Cones to Filtration by the use of the Sprengel pump, which had recently been introduced for the production of reduced pressures, Professor Munroe devised the Rubber Gasket by which the cones could be hermetically connected with the filter pump by an elastic seal. This Rubber Gasket was adopted by Professor G. C. Caldwell of Cornell University in his development of the Perforated Porcelain Crucible, and by Professor F. A. Gooch of Yale University in the development of his Asbestos Felt Filter. Later, Professor Munroe invented his Metallic Felt Filters. Although

he produced filters of finely divided metallic iron, nickel, copper, and other metals, upon supports of the same or other materials, his preferred form for precise work was a felt of metallic platinum, supported in a perforated platinum crucible.

Following his invention of a method for the production of a porcelain biscuit of uniformly fine porosity, Professor Munroe applied this to the production of refrigeration by the use of water only, thus eliminating the use of ice. His prime object was to apply this method to refrigerator cars, where the motion, when the cars were under way, would promote evaporation and consequent cooling, but he also applied the method to household refrigerators, in which by the use of water only, he secured temperatures as low as 56° F. in the hottest weather. Under the title, "Improvement in Refrigerators," he was granted U. S. Patent No. 116,344, on June 27, 1872. To those skilled in the art, it is obvious that this device was a descendant from the well-known "water monkey" and, therefore, based on a well proven principle of action.

Professor Munroe appeared first as an expert in patent litigation in 1872, in the famous Nickel Plating patents, which are so frequently cited in patent literature, and he has since that time repeatedly appeared in a great variety of arts. He was for long the chairman of the Committee on Patents of the American Chemical Society.

Entrusted by our Government with the investigation of many technical problems, he has done distinguished and effective work that is recognized, not only in the Executive Departments and Independent Establishments of the Government with which he is connected, but throughout the world.

It was during Professor Munroe's public service at the Naval Torpedo Station at Newport that he invented *indurite,*[1] the first smokeless powder adopted by the United States Navy for use in the large guns. He mentioned this invention in the course of his remarks "On the Development of Smokeless Powder," his Presidential Address delivered before the Washington Section of the American Chemical Society, February 21, 1896. His experiments with smokeless powder manufacture began in 1889. "At this time the remarkable results pub-

1 U. S. Patent No. 489684.

lished from France, and the announcement that that country had adopted a smokeless powder, had produced their desired strategic effect. All her rivals were seeking to be equally well equipped and were hastening to adopt a powder even before its qualities were thoroughly proven. The newspapers contained remarkable accounts of their performances and alleged descriptions of their methods of production, which, while interesting as news and conveying valuable suggestions, could not be relied upon as to accuracy in details."

Official records in the archives of the Navy recite the history of these investigations and of the successful work performed at the torpeda station. Secretary Tracy, in his report for 1892, said, "it is a gratifying fact to be able to show that what wo could not obtain through the assistance of others, we succeeded in accomplishing ourselves, and that the results are considerably in advance of those hitherto attained in foreign countries," and President Harrison, in his annual message to the Senate and House of Representatives, December 6, 1892, called attention to this development as one of the achievements of his administration.

Dr. Marcus Benjamin,[2] in an address delivered before the Congress of Arts and Science at St. Louis, in September, 1904, hails Professor Munroe as the first in the world to prepare a "smokeless powder that consisted of a single substance in a state of chemical purity."

Another remarkable discovery made by him while stationed at Newport was a principle of detonation. This discovery—known as the *Munroe effect*—throws a light on the nature of the detonation wave and may well be the key to airplane bombing. Briefly, he discovered that if letters, such as "U. S. N. 1884," were sunk into the face of a gun-cotton cube and this detonated in contact with a steel plate, the letters would be indented on the plate. If the letters were raised above the surface of the gun-cotton cube, placed in contact with the steel plate and the cube detonated, the letters would be faithfully reproduced on the plate as before, but raised above the surface thereof. In other words, it was discovered that the further molecules of explosive belonging to the group in proximity to the plate gathered energy as they traveled. By placing the ends of sticks

2 "Some American Contributions to Technical Chemistry," Science, N. S. Vol. XXI, No. 545, 873-84.

of dynamite forming a bomb in an eschelon formation, those at the centre of the group of sticks being perhaps a few inches further from the end of the bomb than those on the outer edges, an increased penetrating effect could be obtained on detonation of the bomb.

"Professor Munroe," says Marshall[3] in his description of the *effect,* "carried out a number of interesting experiments with these charges, and found that the more he hollowed out the face resting on the iron plate the greater was the depth of the depression formed, until, when the charge was completely perforated, it perforated completely the iron plate. When he interposed such articles as a piece of lace or the leaf of a tree or a coin between the hollow charge and the plate, he obtained a detailed impression of the article on the iron, the raised portions of the objects forming the raised impressions. The effect is much the same when the cartridge is removed some distance from the surface of the iron or steel plate, and under water the results are similar to those in air. By tying a number of dynamite cartridges round an empty tin and firing them with a priming charge also of dynamite, Professor Munroe was able to make a considerable hole in a stout safe, whereas a similar charge made up in the ordinary way merely produced a concavity, but no perforation. (Executive Document No. 20, 53rd Congress, 1st Session, Washington, D. C., 1894.)"

The hypothesis explaining this phenomenon is most interesting. "It is evident," continues Marshall, "that, although the products of detonation are gases and have a very high temperature, they must possess in the wave front a density even greater than that of the solid explosive. The wave consisting of such gas constantly renewed, advances through the explosive with a velocity of several thousand meters a second. Where the wave is in contact with the boundary of the explosive the gas flies off at right angles to the boundary and a fresh wave is formed of compressed air, or of whatever other material the surrounding medium consists. This secondary wave is inclined to the original one, but advances much in the same way as the bow-wave of a ship. In the axis of the hollow of one of these bored-out charges the waves of highy compressed air come together with enormous violence, and necessarily produce

3 Marshall, A. "The Detonation of Hollow Charges," Jour. Soc. Chem. Ind., XXXIX, No. 3, p. 35T, January 15, 1920.

a blast in the same direction as the original wave of detonation. This is not only much more intense than the original waves, because it is more concentrated, but it also lasts longer, with the result that the metal plate is carried right away. As one would expect, a charge with a cylindrical hollow bored in it produces quite as deep a hole, if not deeper, than one with a conical hollow. Although a hollow cartridge produces a much greater effect, it does not exert nearly so great a total shock as a whole charge, as is shown by the fact that when detonated on a lead cylinder it does not compress it to the same extent."

The results of some of Professor Munroe's experimental work with his *effect* are seen in the form of beautiful impressions made of leaves, laces, etc., upon squares of armor-plate, fashioned into a unique fire-screen and presented by him to the Cosmos Club.

Of Professor Munroe's many contributions to his favorite study of chemistry, it cannot but be felt that his great work on Chemical Technology, prepared for the Bureau of the Census, is by far the most important. Considering it along with the younger Silliman's contributions to American Chemistry, presented at the Northumberland celebration of the centenary of the discovery of oxygen in 1874, it would be possible to write the history of American Chemistry. In Bulletin 92 of the Census of 1905, Professor Munroe pointed out the close relationship of invention to manufacture, and the importance, in arriving at any true estimate of the growth of manufacture, of correlating patent with the data of production. He was the first to point out this relation and to demonstrate it. In all subsequent Census publications, Professor Munroe summarized the Patents issued in connection with each of the arts, so that his lists are complete summaries from the founding of the Patent Office up to the date each Bulletin was written. He has thus summarized many thousand patents in the chemical industry.

The late Professor Chandler characterized his work on "Chemicals and Allied Products" as "invaluable." He considered it "the most valuable publication to a chemist that has ever emanated from the Census Bureau," and as one that would "never lose its value to the chemical profession." Professor Munroe's monograph on "Petroleum" is said to be one

of the most exhaustive reports ever issued on the subject. The value of these reports as aids in chemical education has recently been pointed out by Professor Mattern.[4]

Since its inception, Professor Munroe has been connected with the National Research Council as Chairman of the Committee on Explosives Investigations, conducting, in this capacity, much valuable work, among which may be mentioned that on ammonium nitrate. He is also Chief Explosives Chemist of the Bureau of Mines and was one of its active organizers. In addition to these duties he is prominently engaged in consulting work for the Assay Commission, the Civil Service Commission, and as consulting expert to the War and Navy Departments. He was retained for many years by the Aetna Powder Company and has been engaged in a similar capacity by at least ten governments.

Professor Munroe's scientific contributions to the literature of chemistry testify eloquently to the inestimable service which he has rendered to his profession.

For some forty years he has been engaged upon a bibliography of explosives. He started with page 1 of volume 1 of the Philosophical Transactions of the Royal Society, dated 1665, and has scanned every page up to 1907, recording the articles relating to his subject found in these volumes. He has thus, among other journals, summarized the American Journal of Science; Journal of the American Chemical Society; American Chemical Journal; Comptes Rendus; Annallen der Chimie Physicalishe; Dingler's Polytechnical Journal; Journal Chemical Society; and the Journal of the Society of Chemical Industry. During his career at the United States Naval Academy, and subsequently at the Torpedo Station, extensive contributions were made by Professor Munroe to the Proceedings of the United States Naval Institute, in relation to the literature of explosives. He is now engaged upon the Berichte.

A master in expression and interpretation of fact, his scientific papers and monographs are a part of the enduring records of the history of science.

During more than half a century of teaching chemistry,

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4 "The Use of Charts and Graphs in Showing the Growth of Chemical Industries," Louis W. Mattern, Jour. Chemical Education, Vol. 2, No. 8, August, 1925.

Professor Munroe's activities were not confined to the University lecture room, for he contributed, under the auspices of scientific and educational institutions, to the furtherance of the knowledge of chemistry among the people through his numerous public lectures.

In addition to the direct educational work undertaken and carried out by him, he has maintained an active interest in organizations which have to do with the diffusion of knowledge. He has devoted himself to this interest particularly in its application to the science of chemistry and also in its relationship to the chemist as a human being. He was elected a member of the American Association for the Advancement of Science at its Portland meeting in 1873, and participated in the organization of the subsection on chemistry, of which in 1880 he was chosen secretary. In 1874 he was advanced to the grade of Fellow, and in 1888 presided over the section with the rank of Vice-President of the Association. He was a charter member of the American Chemical Society, and in 1898 its President. Mainly through his indefatigable efforts and wise leadership, the Society was raised from the status of a parochial organization to that of a national society. This period marked the turning point in its existence, and since then its growth and influence has been most remarkable. He was a founder member and the organizing chairman of the Rhode Island Section, the first section formed. He is an Honorary Fellow of the American Institute of Chemists and has contributed greatly to its influence. Among other organizations of which he is an active member are the American Academy of Arts and Science, American Philosophical Society, and the Washington Academy of Sciences.

Foreign governments and scientific societies have conferred many honors upon Professor Munroe. In 1888 he was elected a Fellow of the Chemical Society of London, and in 1901 he was decorated Commandant of the Order of the Medjidji by the Sultan of Turkey. The Swedish Academy of Sciences appointed him in 1900 to nominate the candidate for the Nobel prize in Chemistry. He is a member of the English and German Chemical Societies and has been a member of four International Congresses of Applied Sciences and of the Second Pan-American Scientific Congress. He belongs to the

Boston City Club, the National Arts Club of New York City, Chevy Chase Club, and enjoys the distinction of having served twice as President of the Cosmos Club.

Although actively and constantly engaged in a variety of pursuits of a highly technical nature, and while many and manifold have been his duties, it is primarily as an educator that one thinks of him. His remarkable power of presentation, seen reflected throughout his career in the wide extent over which he has been sought to clarify issues in judicial proceedings, made him an inspiration in the class-room, where this crowning qualification of the teacher was heightened and intensified by the unmistakable distinction of his appearance. Of modest deportment and demeanor, yet evincing a full measure of that self-respect begotten of the intention to do the greatest good that is practicable, on the rostrum his benign countenance shone with his accumulation of the humanities mixed with the force of his mastery of the subjects of his instruction; and, on nearer acquaintance, his hopsitality and the charm of his discourse have always confirmed every favorable impression of his exterior.

The rare combination in Professor Munroe of the highest scientific attainments with a charming and forceful personality commands respect for his work and engages the affection of those who come into contact with him. Distinguished by the simplest and most lovable human qualities, his ready sympathy, his modulated voice, his clear, twinkling eyes, his hearty laughter, his power to enthuse and inspire, are the things which make it a privilege to have him as a preceptor and friend.

I gratefully acknowledge my indebtedness to Mrs. E. Couch, Dr. Harvey W. Wiley, Dr. Marcus Benjamin, Mr. George W. Littlehales, Dean W. A. Wilbur, Mr. S. P. Howell, and T. A. Witherspoon, Esq., for assistance in assembling this material.

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[This Bibliography, consisting of 258 references, will be completed in the May number.]

How Yeasts Grow

By O. E. Underhill, Normal School, Salem, Mass.

(This is the seventh of a series of question and answer lessons.)

The class has been studying the general topic "Heat." After studying the way in which heat is produced and distributed in the home, the question arises as to other ways of controlling heat. This leads to two lines of thought. The one is refrigeration; the other, personal comfort in winter and summer; which leads to a study of the function of the skin in this respect, clothing, and a study of textiles. It is the first branch of the subject, namely, refrigeration, that is to be followed through in this lesson. The class has studied the refrigerator, its insulation, the convection currents, and so on.

Teacher. While we have been studying about refrigeration John has made an iceless refrigerator. He has been kind enough to bring it to school today, to show to you, and he will tell you all about it and how it works. (*John presents his topic.*)

(Full directions for this project may be found in the U. S. Dept. of Agriculture pamphlet, Food Thrift Series No. 4.)

That is fine, John. But why are we going to all this trouble to keep our foods cool?

Mary. So that the food will not spoil.

Teacher. How does keeping foods cold prevent them from spoiling? (*Pause.*) Doesn't anyone know? . . . What makes food spoil? . . . How do you know when food is spoiled?

Alfred. It smells bad.

Mary. It looks funny sometimes.

Teacher. What do you say has happened to the food when it smells bad, Alfred?

Alfred. We say it is rotten.

Teacher. Yes, one way in which foods spoil is by rotting. Does food ever spoil in any other way besides rotting?

Beatrice. Bread gets moldy sometimes.

Teacher. Yes, Beatrice, that is another way in which foods spoil—by molding. Still another way? . . . Does anyone remember ever having heard of catsup spoiling—or jam—or grape juice?

Charles. Catsup works sometimes.

Teacher. What do you mean when you say that catsup "works"? . . . How does it taste?

Charles. Sort of sour and biting.

Teacher. Does anyone know what we call this process which

makes foods go sour when they spoil? . . . I will tell you. We say the food ferments. The process is called fermentation. That is such a long word, you had better write it down, so that you may learn how to spell it. Now you have told me three ways in which foods spoil. Will you name all three, Dora?

Dora. Foods spoil by molding, rotting and fermenting.

Teacher. That is right. Now I am going to show you something about the fermenting of foods. I have here a pint bottle of molasses which I will mix with water enough to fill this large bottle (*a 2½ liter acid bottle*). Now I will mix this yeast cake with a little water and add it to the molasses and water. Then I will put in this rubber stopper carrying a rubber tube leading into this smaller bottle filled with water and inverted in this pan of water. *(A regular pneumatic trough set-up for collecting gases over water.)* Now I want you to watch this carefully for a few days and see just what happens. By the way, what do we use yeast cakes for?

Flora. To make bread.

Teacher. How many here can make bread? *(Several hands are raised.)* What do you put together in making bread? *(Several things are named.)* Go to the board and make a list of the things that are used. *(Various pupils go to the board until the following list is made.)*

flour	soda	salt
sugar	water	saleratus
yeast	milk	raisins
baking powder	molasses	oatmeal

(This is an actual list as put on the board by members of a seventh grade class.)

I think if you put all those things in you will have some very funny bread. *(Several hands are raised as pupils know some of the errors in this list.)*

John. You don't put sugar in bread. That would make cake.

Dora. Yes, you do put sugar in bread, I know you do. And you don't use baking powder in bread. That is for biscuits.

Teacher. We haven't time to decide this now. I want you to copy tis list and take it home. Ask your mother about it, and find out just what things are used and why each thing is put in. Be ready to tell me about it next time.

NEXT LESSON

Teacher. Tell me what you have noticed happening in the bottle of molasses and yeast.

John. It has been giving off a lot of bubbles.

Charles. I counted them and it has been giving off nearly twenty-five a minute.

Mary. The little bottle has been empty for a long time.

Teacher. I will put another bottle here and let it be filling while we are talking. Mary, you said the bottle has been empty for a long time. What made it empty?

Mary. Bubbles came out of the big bottle and went into the little one and pushed the water out.

Teacher. Bubbles of what?

Mary. Air bubbles.

Teacher. What makes you think that they are air bubbles, Mary?

Mary. They look like air.

Teacher. What does the gas look like that I made for you several weeks ago and showed you how it made things which were burned in it burn so very brilliantly? What does the gas look like that I made from acid and zinc, that exploded with a loud noise when mixed with air and lighted; and the gas that was formed when things burned, and which I showed you came from a bottle of tonic and from a fire extinguisher, and in the air you breathe out? What did those gases look like, Mary?

Mary. They all looked like air.

Teacher. Then how can you say that the gas coming out of this bottle is air when you have only looked at it? Now, Mary, if the bubbles of gas pushed the water out where is the gas now?

Mary. It is in the bottle.

Teacher. But you told me a minute ago that the bottle had been empty a long time.

Mary. Oh, it isn't empty, it is full of the gas.

Teacher. That is right. Now I want to find out what this gas is. How can I tell if it is one of those gases I have just spoken of a moment ago? Will someone tell me the names of all the gases we have studied that look like air?

Charles. Oxygen, hydrogen, carbon-dioxide and nitrogen.

Teacher. All right. Now how can we find out if this gas in the bottle is one of those four?

George. Put a glowing splinter into the bottle. If it is oxygen the splinter will burst into flame. If the gas is hydrogen it will take fire and burn, and if it is either carbon-dioxide or nitrogen the splinter will go out.

Beatrice. You could try it with lime-water to see if it is carbon-dioxide. *(It is assumed that the class has had this test when studying products of combustion.)*

Teacher. George, you take one bottle and test it with a splinter. Beatrice, here is some lime water, you test the other bottle for carbon-dioxide.

George. The splinter goes out, it isn't oxygen or hydrogen.

Beatrice. The lime water I poured in has all turned white. It must be carbon-dioxide.

Teacher. Yes, it is carbon-dioxide. Where must it have come from?

John. The molasses and water—or the yeast.

Teacher. Have you noticed any change taking place, other than the gas forming?

Harry. The molasses is a lighter color.

John. The yeast has gone to the bottom, and there is a whole lot of it.

Teacher. There is certainly a lot more yeast in there than we put in, and the reason the molasses is a lighter color is because there is a lot of yeast mixed in with the molasses. Now if the yeast has increased in quantity we wouldn't be so likely to expect the yeast to have changed into the gas. That leaves the molasses and the water, then. What is carbon-dioxide made of?

Dora. The elements carbon and hydrogen.

Teacher. And what are elements, Dora?

Dora. They are the things out of which everything else is made and there are about ninety of them.

Teacher. Does anyone know what molasses is?

Earl. When we studied geography we learned that it was what was left after the sugar was crystallized from the juice of the sugar cane.

Teacher. Yes. It is mostly sugar. And how does the plant make sugar?

Earl. It puts carbon-dioxide from the air with water from the soil together in the leaves of the plant.

(See "The Two Chemists, Chloro and Phyll," Gen. Sci. Quart., May, 1924, for teaching lesson on photosynthesis.)

Teacher. You see, then, that the carbon in the carbon-dioxide must come from the sugar in the molasses. The yeast tears the sugar molecules apart and builds up molecules of carbon-dioxide and molecules of alcohol. The alcohol is left in the bottle mixed up with the molasses. It would take too long to get the alcohol out of the molasses now, but after school I will set up an apparatus for getting the alcohol out and show you that it is really there and will burn, if any of you care to have me. The yeast uses the sugar as food. Do you remember how we used the first letters of the elements to represent them in order to show how they moved around when a fuel burns; and how we put those letters together in order to show what elements make up the different things? Just to refresh you memory I will put one or two of them on the board. (*Writes CO_2 and H_2O.*) Now, James, what do those stand for?

James. The first one stands for carbon-dioxide and the second one for water.

Teacher. Right. Mary, tell us what the letters and numbers mean.

Mary. The first one means that one little piece of carbon and two little pieces of oxygen are put together to make a piece of carbon-dioxide.

Teacher. That is right, Mary, but I told you the names of those little pieces. Do you not remember them?

Mary. The small pieces of the elements are called atoms and the piece of carbon-dioxide formed is called a molecule.

Teacher. That is right. Now, tell the class what the other formula means and use the right names for the particles.

Mary. Two atoms of water combine with one atom of oxygen to form a molecule of water.

Teacher. That is it. Now I am going to put the formula for sugar on the board and see if you can tell me what sugar is made up of. (*Writes $C_6H_{12}O_6$.*)

(I prefer this rather than the formula for cane-sugar, because it does away with the complications produced by having to add the molecule of water in order to make the equation balance.)

John. It means that in each molecule of sugar there are

six atoms of carbon, twelve atoms of hydrogen and six atoms of oxygen.

Teacher. Good. Now I will show you what the yeast does to these atoms when it pulls the sugar molecules apart. *(Writes* $C_6H_{12}O_6 = 2C_2H_6O_6 + 2CO_2$. You see that for every molecule of sugar that the yeast tears apart, it builds up two molecules of carbon-dioxide gas and two molecules of alcohol. Now I am going to take a drop of this molasses and yeast, place it on a piece of glass and place it under a microscope for you. After you have looked in the microscope, go to your desk and try to draw what you have seen. *(Pupils look at yeast and go to seats to draw. Teacher helps with questions and comments, those who are not successfully getting the idea.)*

(Of course it would be better to draw while at the microscope, but many schools have not a sufficient number to allow more than two or three to be used at once.)

John, draw your picture on the board. Make it quite large. *(John draws.)* That is fine, John. Class, you see these single ovals in John's picture? Each one represents a yeast plant; for yeast is really a tiny plant. Each plant is just one little cell, too small to be seen by the eye alone. Now what do you suppose is happening to these cells with little bunches on the sides?

Mary. Perhaps they are growing.

Teacher. That is just what they are doing. Each little yeast cell eats the sugar and starts to grow by putting forth a tiny bunch. This bunch keeps growing and growing until it gets as large as the cell it started from. Here is such a double cell here. *(Points to picture on board.)* Then the two cells separate, and you have two separate yeast cells grown from the one. Here is one which has just separated. *(Points.)* This is the way in which yeast cells reproduce. This growth that starts out from the side of a yeast cell looks like a little bud, so the process is called budding. We say yeasts reproduce by budding. Now I wonder if you know just what we mean by reproduction? Who can tell me?

Frank. It means growing.

Teacher. You mean that because you are taller now than you were three years ago you have reproduced?

Frank. No, that isn't it.

Teacher. But that is growing, isn't it?

Frank. Yes.

Teacher. Then growing and reproduction are not quite the

same thing, are they? What do we mean when we say flowers reproduce—or animals?

Mary. It means that more plants or animals come like the first ones.

Teacher. Yes. When any living thing produces others just like them we call that reproduction. Now you have learned how yeasts grow and reproduce. You have also told me that yeasts cause foods to spoil. Where do the yeast plants that cause foods to spoil come from? *(Pause.)* Under what conditions does your grape juice work—or your jam?

Beatrice. If it isn't tightly closed or is left with the cover off.

Teacher. Where must the yeast come from, then?

Beatrice. From the air?

Teacher. Yes. These plants are so small that some of them are floating around with the dust of the air all the time. When they fall into things that contain something that they can feed upon, they cause it to work or ferment and spoil. But how did we get to talking about yeast plants, anyway?

Alice. We were talking about how foods spoiled.

Teacher. Oh, yes. And how did we happen to be talking about that?

Alice. We were trying to find out why we kept foods cool to keep them from spoiling.

Teacher. Well, we seem to have gotten quite away from the icebox, haven't we? We usually cover up things tightly to keep them from being spoiled by yeast plants, but putting them in the icebox would help, too, because the yeast cannot grow very well in a cold place. *(An experiment to show this might have been worked in here.)* When we study about the other ways in which foods spoil I think you will see more why we keep them cool to prevent the spoiling.

But yeast can be helpful as well as harmful. You know we use yeast in making bread. I have asked you to find out what is used in the making of bread and why the different things are used. We haven't time for that now, but I will ask you to tell me about it next time. Perhaps you can find out some other ways in which yeasts are helpful. Then we will talk about another way foods spoil, that is by molding.

(From this point a discussion of bread making, yeast as a source of carbon dioxide, and yeast as a source of alcohol, may be had. A good book for supplementary reading is "Bacteria, Yeast and Molds in the Home," by Conn)

Must Science Go the Way of the Classics?

From the

Annual Report of the President of Columbia University

For two generations a very considerable part, perhaps a major part, of the effort of educational systems and institutions has been expended upon the development of teaching and research in the natural and experimental sciences and in making adequate provision for this work in men, in laboratories and in apparatus. When the movement for extensive study of the natural and experimental sciences began, it was more or less stubbornly resisted by the college faculties of the day. Undoubtedly because of this fact, some scientific schools were founded quite apart from existing colleges and universities, such as the Rensselaer Polytechnic Institute in 1824 and Stevens Institute in 1870. In other cases, schools of science were incorporated in existing institutions for higher education as distinct and more or less independent and autonomous units. This was the case at Harvard where the Lawrence Scientific School was founded in 1847, at Yale where the Sheffield Scientific School was founded in 1854 and given its present name in 1863, and at Columbia where the School of Mines was founded in 1864. Gradually, however, the opposition to science study and science teaching broke down, and these new and highly important subjects were incorporated everywhere as part of the program of study in the elementary school, in the secondary school, in the college, and in the university. Meanwhile the domain of science itself has expanded by leaps and bounds. New knowledge of the most amazing and unsuspected kind has constantly been revealed by eager investigators. The steadily improving microscope and newly discovered instruments and methods of precision and measurements gave man a grasp of the infinitely small which no imagination could have forecast a few years earlier. Applications of scientific knowledge to practical life and to industry are multiplied manyfold, and the daily life of millions of human beings is revolutionized and made vastly more comfortable, more safe and more healthy in consequence.

The essential fact in all scientific study is the use and the

comprehension of the scientific method. Nothing is to be taken for granted and no test, whether quantitative or qualitative, is to be overlooked. Every conclusion as it is reached is held subject to the results of verification, modification or overthrow by later inquiry or by the discovery of new methods and processes of research.

One would suppose that after half a century of this experience and this discipline the popular mind would bear some traces of the influence of scientific method, and that it would be guided by that method, at least in part, in reaching results and in formulating policies in social and political life. If there be any evidence of such an effect, it is certainly not easy to find. Passion, prejudice, partisanship, unreason still sway men, whether as individuals or in the mass, precisely as if scientific method had never been heard of. How is it possible that with all the enormous advances of science and with all its literally stupendous achievements it has produced such negligible results on the mass temperament and the mass mind? This is a question which may well give us pause, for something must be lacking if intelligent men and women, long brought into contact with scientific methods and scientific processes, pay no attention whatever to these, and show no effect of their influence, when making their private or public judgments.

One begins to suspect that the teachers of science themselves may have failed in making effective their science and their scientific method in this sphere of their larger usefulness. There can be no question that the decline in interest and authority of the ancient classics as educational instruments was hastened by, and indeed was in no small part due to, the manner and method of teaching those subjects that became substantially universal some sixty years ago. Minute matters of grammatical, linguistic and archæological importance were dwelt upon and magnified to the exclusion of the larger and broader interpretation of the meaning of the life, the thought, and the civilization of the ancient Greeks and Romans. Emphasis was increasingly laid upon the training of accurate and meticulous classical scholars, which was all well enough in its way, but which was something quite different from using the ancient classics as effective and stimulating educational instruments for the great mass of men. It is a sorry, but safe, re-

flection that had the classics been properly taught and presented in school and in college they would not now be in their parlous situation. Can it be possible that something of the same sort is about to happen in the case of the natural and experimental sciences? If these subjects are to be presented only for the purpose of training specialists, and if the methods to be followed are those that, while appropriate for investigation, have no relation whatever to interpretation, then it may well be that in another generation general interest in the natural and experimental sciences and general knowledge of their meaning and significance will have greatly declined. If these disintegrating forces are at work, then it is quite useless to cite present statistics as to the extent and popularity of science teaching and science study as evidence that existing conditions will continue indefinitely.

If one desires to be a physicist, a chemist, or a biologist, and is ready and willing to devote his time and his energy to that end, then the methods now in vogue in the colleges and universities are excellent. If, however, one wishes to know what physics, chemistry and biology are about, how they came into existence, what has been their history, who have contributed in most important fashion to their advance, how they are related to each other and to other branches of knowledge, and what is the significance of their present conclusions and applications, then he will find it very difficult indeed to get guidance or help from any teacher of physics, of chemistry, or of biology. In fact, many of these teachers do not possess this sort of knowledge. This was not always the case. Faraday could interpret as well as investigate and stimulate investigation; Helmholtz and DuBois Reymond were past masters of the art of scientific exposition and interpretation; so were Huxley and Tyndall and Kelvin. Why must the science teachers of today turn their backs upon the example and the achievements of these great masters, and neglect the opportunity which is daily offered to make science and scientific method a real and commanding factor in the life of tens of thousands of human beings by explaining to them what science is all about? The making of a few score of admirable specialists, the training of a few hundred research students and the annual production of a small army of youth with narrow, if minute, information useful in some particular vocation, is a sorry substitute for

reaching the great mass of the population with the influence and the ideals of scientific inquiry and scientific method.

Nothing can so quickly or so surely kill any subject of instruction and deprive it of its influence as an educational instrument as uninspiring teaching or the stubborn insistence upon false methods. Surely, the example of the ancient classics ought to suffice. They were killed largely by those who taught them. Men of light and leading are everywhere trying to resurrect the classics from their academic grave and to reestablish them where they belong as a chief foundation of all liberal education. It would be poor business indeed if, while the ancient classics are being resurrected, the natural and experimental sciences should be led by their teachers into the valley of the shadow of academic death.

What is Mercerized Cotton?

Some confusion exists in the minds of many housekeepers as to the distinctions between "mercerized" cotton goods and those fabrics having more or less temporary gloss finishes produced by paste mixtures. "Paper cambric" is an example of a fabric with the paste finish. Artificial silk, or rayon, is a more lustrous fabric than either of these, but should not be mistaken for mercerized cotton.

Many years ago, says the United States Department of Agriculture, John Mercer, for whom the process is named, discovered that when cotton yarn or cloth was dipped in strong solutions of lye for a short time and then washed, neutralized, and dried it became much stronger. In later years it was noted that if the yarn or cloth was held under well-regulated tension during the process it was rendered glossier as well as stronger. Hence mercerization is a process that adds not only durability but beauty. There are today on the market many cotton fabrics in which the entire cloth is glossier and stronger than ordinary cotton materials or in which bright mercerized yarns have been introduced to form stripes, checks, or figures.

Submarines Vie With Door-Bells at Observation

From "School Topics," the Official Magazine of the Public Schools of Cleveland.

Submarines, sewing aprons, door-bells and boomerangs are being discussed in the 6A grade at Observation Training School, where pupils are explaining construction of such objects as training in oral English.

Pupils are told to choose any article they desire and explain "how to make it." Hence, a great variety of subjects are discussed. Positive and negative currents, batteries, voltage, and other technical terms were flung about with ease by a boy explaining how to install a door-bell. The necessary materials were on hand to make the explanation more graphic, and also to create an "English situation." When the boy said *this here* wire he was corrected by a watchful pupil. A diagram was made on the board to show a part of the door-bell in operation.

A question arose as to whether a certain type of battery was used for lights on a Ford car. Everyone had different opinions, so the chairman appointed a boy to get some definite information on the subject. Here the teacher, sensing that the boy had a vague knowledge as to what he was to look up, said, "Now exactly what is it you want to find out?" This crystalized the question and enabled the pupil to go ahead with his investigation.

"How the Australians make boomerangs," was a subject chosen by another boy who had made one of cardboard to show the construction. A discussion of hickory wood as material, of whether the wood should be soaked in hot water or steamed, and other related facts of boomerang construction showed that the pupils were actually interested in the explanation.

The girls came into the picture when one described the steps in making a sewing-apron, giving the materials and showing the completed apron.

After each discussion the chairman asked, "Did he accomplish his purpose?"

In order that the class might judge whether he did or not, the purpose had been written on the board. It read, "To make the explanation so clear that the listener will get a vivid picture and will be able to follow your instructions."

Although the lesson was socialized, the teacher stepped in if some omission or incorrect impression was being made. After the lesson was over she handed slips to all who had recited, containing suggestions for improvement in their English, or in some other phase of the work.

Some Ways to Know the Bargains in White Goods

To many homemakers the midwinter "white" sales offer the best opportunity of the year to stock up on sheets, pillowcases, towels, and other household textiles. But all is not good that's white. Just as in buying other fabrics, there are facts about fibers and weaves that the homemaker needs to know if she would get a true bargain, says the Bureau of Home Economics of the United States Department of Agriculture.

If buying yard goods, unravel a yarn, untwist it and pull out small tufts of the fibers. Notice whether they are about the same or very different in length. The fabric with longest fibers of regular length will wear best. The ends of short fibers work loose and make the fabric fuzzy, as the sizing put in by the manufacturer is washed out. The lint rubs off from such a fuzzy fabric and it soils more readily.

Notice whether the yarns are even and equal in size. Irregular yarns make lumps that cause the fabric to wear through quickly at those points. Loose ends on the surface, left from knots in the yarns, are likely to catch during laundering and make holes in the fabric. Cloth with these defects is often sold as a second, and the buyer should not be surprised if it shows signs of wear rather quickly.

To judge the firmness of the weave, pull the fabric on the straight and on the bias, first one way and then another. Scratch it with the finger-nail. Note whether the yarns slip out of place easily. The closer the weave the more durable the fabric, other things being equal. If the weave is very loose, be prepared to have the fabric shrink when it is washed.

Rub a corner of the goods briskly between the fingers to see whether it contains a great deal of starch or other sizing. Best of all, if you can, take home a sample and wash it. Mercerizing is a permanent finish given to cotton that makes it more lustrous and stronger, and should remain after washing.

Available Motion Picture Films

The Motion Picture Bureau of the Y. M. C. A., with headquarters at 120 West 41st Street, New York, has recently opened a Chicago exchange at 1111 Center Street. The Bureau has recently issued an up-to-date list of industrial films which are available to Y. M. C. A.'s, churches, schools, industries, business, welfare and other organizations free of charge except for the payment of transportation costs. These films are theatre standard width, and those at the Chicago exchange are non-inflammable.

Sugar Pictures

Ten billion pounds of sugar per year are required to satisfy the American sweet tooth. The average person in the United States consumes more than 90 pounds of it each year, according to the United States Department of Agriculture educational film productions, "Sugar Cane and Cane Sugar," and "Beets from Seed to Sugar Bowl."

Although only a bare one-fourth of the sugar we consume is home grown, sugar-beet and sugar-cane production rank among our important agricultural industries. About four-fifths of the domestic cane crop is grown in Louisiana, while Michigan, Minnesota, Colorado, Utah and California are prominent sugar-beet states.

Sugar cane was introduced into America in early colonial days, while the sugar beet, though older than Christianity, was brought to the New World in recent years. The development of the beet in the United States has been rapid, however, and at present the quantity of beet sugar produced in North America is five times greater than the amount of cane sugar produced on this continent.

Summer Courses in Science

GEORGE PEABODY COLLEGE FOR TEACHERS, Nashville, Tenn.

The Teaching of Biology in Secondary Schools. W. W. Carpenter
The Teaching of General Science in Secondary Schools. H. A. Webb
The Teaching of Chemistry in Teachers' Colleges. H. A. Webb
The Teaching of Elementary Science in the Grades. H. A. Webb

NEW YORK UNIVERSITY, New York City.

Biology—General Principles of Biology. Dr. Hussey
Biology—General Biology for Teachers. Mr. Barrows
The Teaching of Biological Science in the Secondary School. Dr. Wheat
Chemistry—General Inorganic Chemistry. Dr. Miller
The Teaching of Science in High School—Group I, Chemistry; Group II, Physics; Group III, Science in the Trade School. Dr. Bedford
The Teaching of General Science—Group I, General High School; Group II, Trade School. Dr. Bedford

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Diamonds whose properties have been altered by the action of ultra-violet light are restored to their original condition under the action of ultra-red light more quickly than when kept in the dark.

Gas lighting of cars is gradually giving way to electric lighting. The "straight storage system" of car lighting has almost disappeared. The "head end system," in which the current is obtained from a steam-driven dynamo in the baggage car, is also going out of use. The "axle generator system" is being used in their places. In this system each car is its own power plant, having a dynamo operated from the axle of the car. This dynamo provides current for lights and charges a storage battery which gives current for lights when the car is not moving.

Progress has been made towards producing a gas fiilament lamp of low voltage life. Tests on experimental lamps have given a run of 400 hours without appreciable change. The lamps have not, however, yet reached a commercial stage.

Slow Motion Pictures

A New Aid to Scientific Study

Now Practical and Inexpensive with the

VICTOR CINE CAMERA

The VICTOR AUTOMATIC CINE CAMERA has a special adjustment for taking action at a very high speed so that when the pictures are later projected the effect of "Slow Motion" is obtained.

For instance, a record breaking "hundred yard dash" in slow motion pictures would show the runner in a series of apparently effortless, graceful, deliberate strides—whose slow movements would afford ample opportunity for intensive study and instruction.

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CHICAGO

The New Books

Life and Evolution—Homes—449 pages—227 cuts—$3.50—Harcourt, Brace and Company.

"The aim of the present volume is to serve as an introduction to the study of biology. The subject matter has been chosen to meet the needs of general students, rather than prospective specialists in different branches of science. . . . It has been my aim to present those aspects of biology which will best prepare the student for appreciating the great changes in our outlook upon the world, which have resulted from discoveries and generalization in regard to living forms."

This is a fascinating book. It covers the field of elementary biology, yet not in the manner of a text-book. It is most interesting reading and is non-technical enough to be understood by readers untrained in this field.

The first eight chapters cover the structure of plant and animal life, from the one-celled forms to the higher plants and animals. Then is taken up Embryonic Development, The Perpetuation of Life, The Development of Social Life, Association, Regeneration, Heredity and Variation, and Heredity and Environment.

Chapter XVI takes "Organic Evolution," under the heads "Historical Orientation," "General Evidences," and "Evidence from Classification, Morphology, Embryology, Paleontology and Geographical Distribution." The last two chapters are, "How is Organic Evolution Caused" and "The Eugenic Predicament."

Each chapter has a bibliography of supplementary reading. The book contains a glossary of terms used, giving meaning and origin. Every general science teacher should read this book.

Physics Experiment Sheets—Nelson—60 experiments—Globe Book Company.

Directions and data tables are given in a column covering the left half of the page. The right half is left blank for notes and calculations. Thought questions are scattered throughout the directions. Many of these questions require real thought to answer and may not be answered directly from the results of the experiments. Questions to be answered by direct observation in the experiment are given to lead the thought in the right direction and to focus attention on points which might be overlooked by the student.

The Surface History of the Earth—Joly—192 pages—illustrated—$3.00—Oxford University Press, American Branch, New York.

"The surface history dealt with in this book is based directly upon two great recent advances in our knowledge of the earth's crust: the radio-activity of the rocks and isostasy."

This book brings forth some new and startling ideas. The moon as the source of tides in the liquified substratum of the earth, allowing the accumulated radio-active heat of ages to escape, thus allowing life to survive through the great time periods, is one of the ideas presented. "Our old-fashioned gift of rejuvenation: returning age after age to almost the same starting point."

The chapter titles are: 1. The Earth's Surface Structure; 2. Isostasy; 3. The Continents and the Substratum; 4. The Radio Activity of the Rocks; 5. The Decipherment of Surface History; 6. The Source of Revolutions; 7. The Building of the Continents; 8. The Revolutions; 9. Geological Time; 10. The Dominance of Radio Activity.

The Measurement of Achievement in Geography—Branon—186 pages Macmillan Company.

"This book has been written with the hope that other teachers will be assisted to realize the many advantages that come from the use of properly devised tests."

The chapter headings will best give the scope of this book: 1. Use and Value of Tests in Geography; 2. The Need for Objective Tests in Geography; 3. Criteria for the Determining of Test Material; 4. The Selection of Geographical Material for Tests; 5. The Mechanics of Geography Tests; 6. Place Geography Tests; 7. Factual Geography Tests; 8. Problem Tests in Geography; 9. The Classification of the Details of Geography; 10. The Relation of Assisted and Unassisted Memory Recall Tests; 11. Available Tests and Scales in Geography; 12. Practice Tests in Geography; 13. The Interpretation of the Results of Objective Measurements.

Introduction to Fiske Science—Hart—306 pages—199 cuts—$1.50—Oxford University Press, American Branch, New York.

This is a text-book of high school grade. Like many of the English texts it is notably thinner than its corresponding American text-books, but nevertheless covers the ground.

The author of this text says: "No text-book can replace the personality of the teacher. It is for the teacher to insure that the danger of tedium by too much laboratory work must be avoided; it is for him or her to see that the spirit of science is kept alive by that variety of material and method that is so plentifully available to all that seek it. Experiments are given with the text-book work. Experimental work figures largely in the earlier chapters of this book. Gradually, after the method and habit of experimenting become established, the number of formal experiments diminishes, and more rein is given to the descriptive side."

The turpentine and rosin industry is of considerable importance in the United States, as indicated by figures recently put out by the Bureau of Chemistry of the Department of Agriculture. The various industries which use these products in their manufacturing reported that during the calendar year 1924 they used a total of 6,739,000 gallons of turpentine and 864,850 round barrels of rosin. The manufacturers included in these reports are makers of paint, varnish, soap, paper, rosin oil, pitch, printing ink, shoe polish, leather dressings, sealing wax, fly paper, insulating material, oils, greases, linoleum, roofing, automobiles and wagons, malleable iron and steel, pharmaceuticals, woodenware, and the operators of shipyards. Paint and varnish, shoe polish, leather dressings, and the automobile industry use the greater part of the turpentine, while the paper and paper size, varnish, soap, rosin oil, pitch, and printing-ink makers use by far the larger part of the rosin.

Owed to the Chemist

The chemist, they say, isn't getting his due; his salary checks are too meager and few. Not seldom the business depends on his skill; without him the earnings would be about nil. Yet, while he's inventing new things by the score, the credit is left at the president's door. "The chemist? Oh, yes, he plays 'round with his smells, but executive 'pep' is the factor that tells." The chemist works out a new process or two, saving millions that formerly went up the flue. Do they therefore promote him and double his pay, and give him a big block of stock if he'll stay? More likely they tell him that business is bad, that profits are minus and prospects are sad; but if he'll continue to work his poor head off, they possibly might stave the ruin they dread off. For, in spite of the moralists, all of us know that many earn less than the service they show, and an income that runs to the millions oft comes from a Jack-Horner-habit of grabbing the plums. The men with the test-tubes need more self-esteem; they must show they are not as content as they seem. For they'd like to get more than an office-boy's pay, and know that their training was not thrown away. And it isn't for lucre alone they are yearning, although they would like to receive what they're earning; but they want to be valued at what they are worth, and then they will feel more content with their berth.

If chemistry's really important to us, we can't leave the chemists to chafe and to cuss. For virile young men, when they see how they fare, will go into law or take up cutting hair. Now a dearth of trained chemists will leave such a gap, it would mean to the country a big handicap. Employers and chemists and public at large, for the sake of the future, consider this charge. Ignoring the scientist, sooner or late, will bring the whole craft to an ignoble state. And so, if we wish to see science advance, we all must assist its prestige to enhance.

So here's to the chemists, and high may they climb; may they win all the credit they merit in time.—*The Nucleus.*

Science Articles in Current Periodials

[These classified articles should make valuable supplementary reading for the pupils. In some cases the material is in such form that it would be too difficult for many of the pupils to abstract the matter for themselves. In such cases the article may be read by the teacher and passed on to the pupil in class. Such articles are starred. Articles for professional reading are at the end of the classified list.]

AQUARIUM

Building an Aquarium. Sci. and Inv., Mar. 1926, p. 1020.

ASTRONOMY

The Death of the Universe. Lit. Dig., Dec. 26, 1925, p. 16.
*The Study of the Sky in Europe. Sci. Mo., Feb. 1926, p. 89.
Morning and Evening Stars for 1926. Pop. Astron., Jan. 1926, p. 23.
The Moon's Atmosphere. Sci. and Inv., Mar. 1926, p. 1005.

BACTERIA

*Do Bacteria Have Disease. Sci. Mo., Feb. 1926, pp. 123 and 177.

BRIDGES

Bridging the Rivers of the World. Pop. Mechs., Mar. 1926, p. 311.

CLEANING

Origin and Removal of Stains. Dyestuffs, Dec. 1925, p. 176.

COMBUSTION

Fires and Spontaneous Combustion. What is a Fire? Traveler's Standard, Nov. 1925, p. 228.

CONSTRUCTION

Materials of Construction. Journ. of Chem. Educ., Jan. 1926, p. 59.

CRYSTALS

Paper Models of Crystal Structure. Sci. and Inv., Feb. 1926, p. 921.

EARTHQUAKES

*Earthquakes. Sci. Mo., Feb. 1926, p. 141.

FERTILIZERS

*Nitrogen as a Plant Food. Journ. of Chem. Educ., Jan. 1926, p. 50.

FOOD

Our Future Flour Supply. Jour. of Home Econ., Feb. 1926, p. 68.

HELIUM

Helium and Natural Gas. Jour. of Chem. Educ., Jan. 1926, p. 45.

HUMIDITY

How to Put Humidity in Your Home. Hygeia, Jan. 1926. p. 11.

HYDRAULICS

How Floating Drydocks Operate. Sci. and Inv., Feb. 1926, p. 898.

INSECTS

Insects of the Snow. Lit. Dig., Jan. 9, 1926, p. 22.

LIGHT

Black Light. Lit. Dig., Feb. 6, 1926, p. 23.
Michelson Holds the Stop-watch on a Ray of Light. Amer. Mag., Jan. 1926, p. 24.

LINEOLEUM

From Earthern Floors to Linoleum. Pop. Mechs., Feb. 1926, p. 211.

MOON

See Astronomy.

METEORS

Mining for Shooting Stars. Lit. Dig., Feb. 13, 1926, p. 23.

PHYSIOLOGY

How Many Tastes Are There? Li[illegible] Dig., Feb. 6, 1926, p. 22.
Our Danger Points. Lit. Dig., [illegible]. 6, 1926, p. 25.

PRECIOUS STONES

Famous Diamonds. Mentor, Dec. 1925.
Hunting Hidden Treasures. Pop. Mechs., Mar. 1926, p. 419.

RADIO

*Radio Transmission of Music. Sci. Mo., Feb. 1926, p. 158.
(Because of the many magazines devoted to Radio alone, and the extensive departments devoted to this subject in most scientific magazines, radio articles are too numerous to list separately.)

RELATIVITY

Is Einstein Right? Sci. and Inv., Mar. 1926, p. 991.

SAFETY TEACHING

Home Accidents and Their Prevention. Hygeia, Jan. 1926. p. 43.

SILK

Solving Silkworm Secrets. Pop. Mechs., Feb. 1926, p. 228.

SOUND

Teaching Deaf Children to Talk. Pop. Mechs., Mar. 1926. p. 435.

SUBMARINE

A Dollar for Every Dive. Pop. Mechs., Feb. 1926, p. 219.

SULPHUR

Mining Sulphur with Hot Water.

TRANSMUTATION OF ELEMENTS

Have the Modern Alchemists Succeeded? Lit. Dig., Feb. 6, 1926, p. 24.

TRANSPORTATION

Strange Methods of Transportation Where Machines are Still Unknown. Pop. Mecs., Feb. 1926, p. 280.
A Hundred Years of Railroad Progress (10 pictures). Comm. Amer., Feb. 1926, p. 26.

WATER POWER

The Power of Five Niagaras. Sci. and Inv., Mar. 1926, p. 24.

WATER SUPPLY

Water Supplies Graded. Amer. City, Jan. 1926, p. 67.

WEATHER

A Fascinating New Radio Hobby. Sci. and Inv., Mar. 1926, p. 60.
Measuring the Sun's Heat and Forecasting the Weather. Nat. Geog., Jan. 1926, p. 111.
Is the Climate Changing? Lit. Dig., Jan. 8, 1926, p. 18.

PROFESSIONAL

Apparatus Needed for General Science. Sch. Sci. and Math., Jan. 1926, p. 28.
Objectives of Natural Science. Sch. Sci. and Math., Dec. and Jan. 1926.
Science or Sciences. Sch. Sci. Rev., Dec. 1925, p. 707.
What May We Hope from the General Science Course? Sch. Sci. and Math., Feb. 1926, p. 121.

Magazine List

American City. 443 Fourth Ave., New York City. Monthly. $4.00 a year, 50c a copy. The science problems of city and rural communities are treated in numerous articles, well illustrated. A valuable student and teacher reference.

The American Food Journal. 25 E. 26th St., New York City. Monthly. $3.00 a year, 25c a copy. Articles on food manufacture, food legislation, and experiments in nutrition.

Commercial America. Philadelphia Commercial Museum, Philadelphia, Pa. $2.00 a year. Ill. Commercial production. New inventions. Will interest commercial geography and science teachers.

Current Opinion. 65 W. 36th St., New York City. Monthly. 35c a copy, $4.00 a year. Has a regular department "Science and Discovery," containing articles of popular interest, adapted to pupils or teachers.

The Educational Screen. 5200 Harper Ave., Chicago. Monthly. 15c a copy, $1.00 a year. Discusses the use of movies in our schools; gives brief descriptions of educational films and lists theatrical films which are suitable for children. The journal is entirely educational, having no commercial affiliations.

Garden Magazine. Garden City, N. Y. Monthly. 25c a copy, $3.00 a year. Ill. Helpful to amateur gardeners, teachers and pupils.

General Science Quarterly. Salem, Mass. Quarterly. 40c a copy, $1.50 a year. The only journal published devoted alone to science in the elementary and secondary schools. It tells what schools are doing in science, gives lesson plans, demonstrations, and an extensive bibliography of usable articles in current periodicals.

The Geographical Review. Broadway at 156th St., New York. Quarterly. $1.25 a copy, $5.00 a year. Devoted to scientific geography. Original maps and pictures. One department contains condensed items of topics of current interest.

The Guide to Nature. Sound Beach, Conn. Monthly. 15c a copy, $1.50 a year. Ill. Of interest to elementary pupils and teachers of nature study.

Hygeia. 535 No. Dearborn St., Chicago. Monthly. 25c a copy, $3.00 a year. Popular articles on individual and community health. A valuable supplement to classroom work in hygiene.

Industrial and Engineering Chemistry. Box 505, Washington, D. C. Monthly. 75c a copy, $7.50 a year. A technical journal which contains much material which teachers can use.

Industrial Education Magazine. Peoria, Illinois. Monthly. $1.50 a year, 25c a copy. An illustrated magazine, which is indispensable to the shop instructor and to others who would "keep up" in industrial education.

Journal of Chemical Education. Easton, Pa. Monthly. $2.00 a year. Promotes chemical education; primarily a journal for the chemistry teacher. Digests of activities of chemical associations.

Journal of the Franklin Institute. Philadelphia, Pa. Monthly. 50c a copy, $6.00 a year. Ill. A technical journal. Contains many articles of value to science teachers.

Journal of Home Economics. 1121 Cathedral St., Baltimore. Monthly. 25c a copy, $2.50 a year. For teachers.

The Literary Digest. 354 Fourth Ave., New York. Weekly. 10c a copy, $4.00 a year. Has a department "Science and Invention." Articles are mostly digests from other journals. They are popular in nature and suitable for high school pupils.

National Geographic Magazine. Washington, D. C. Monthly. 50c a copy, $3.50 a year. Best monthly journal for high-grade pictures. Articles are of interest to general reader, pupils and teachers, as well as to geographers.

The Nation's Health. 22 E. Ontario St., Chicago, Ill. Monthly. $3.00 a year, 25c a copy. An illustrated magazine devoted to community, industrial and institutional health problems. Very helpfu lto the science and hygiene teacher.

Nature Magazine. 1214 16th St., Washington, D. C. Monthly. 25c a copy, $2.00 a year. A nature magazine, with popular articles exceptionally well illustrated. Includes what was formerly "Nature Study Review."

Popular Mechanics Magazine. Chicago. Monthly. 25c a copy, $3.00 a year. Short science items and articles, well illustrated. Appeals strongly to elementary pupils. Suggests many construction problems.

Popular Science Monthly. 225 W. 39th St., New York City. Monthly. $2.50 a year, 25c a copy. A review in text and pictures of the news of science and invention, presented in a humanistic and inspirational way. Used as a supplement to text-books in many high schools. Valuable to science pupils and teachers.

Monthly Guide for Science Teachers. Issued by "Popular Science Monthly," October to June. 25c a year. A valuable teacher's aid, giving lesson plans, experiments, and many reference suggestions for secondary science teachers.

Practical Electrics. New York City. Monthly. 20c a copy, $2.00 a year. This is especially suggestive to boys who are making things electrical. There are numerous articles on electrical topics.

Radio News. 53 Park Place, New York City. 25c a copy, $2.50 per year. Monthly. A practical periodical for all who are interested in radio. Gives radio progress, new hook-ups, and gives much help to one who may wish to construct his own set.

Review of Reviews. 30 Irving Place, New York City. Monthly. 35c a copy, $4.00 a year. An illustrated monthly covering world affairs. Contains many good articles bearing on science, suitable for class reports.

Safety Engineering. 80 Maiden Lane, New York. Monthly. $3.00 a year. 25c a copy. A journal devoted to conservation of life and property, and contains much material helpful in science classes.

School Science and Mathematics. Chicago. Monthly. $2.50 a year. A teacher's journal. Includes many helpful suggestions.

Scientific American. Woolworth Building, New York. Monthly. 35c a copy, $4.00 a year. Has longer articles than the other popular science journals. Illustrated, and is particularly valuable to high school science pupils and teachers.

Science and Invention. 53 Park Place, New York City. Monthly. 25c per copy, $2.50 a year. Ill. Popular articles on astronomy, physics, photography, radio-activity, medicine, and, in fact, science in general.

Scientific Monthly. Garrison, N. Y. 50c a copy, $5.00 a year. Articles, as a rule, are more along lines of pure science. Much of value to teachers. Articles can be read to advantage by many pupils.

Science News-Letter. Science Service, 1115 Connecticut Ave., Washington, D. C. Weekly. 10c a copy. $5.00 a year. Gives a valuable current summary of the progress of science, in a form usable in science classes.

Transactions of the Illuminating Engineering Society. 29 West 39th St., New York. Monthly. $1.00 a copy, $7.50 a year. Technical. Many articles contain material which can be used in high school classes.

How Fast is the Wind Blowing?

Many people have extremely vague ideas about the velocity of the wind, just as others are unable to gauge correctly the speed with which they may be traveling in an automobile. The two cases are not entirely comparable, because a large, heavy car may be going very fast without giving its occupants that impression, whereas a small, light one will bounce and vibrate alarmingly at a much lower rate of speed.

Our impression of wind velocity, however, may be affected by various factors, such as temperature, moisture in the air, topography, and even the condition of our skins. A cold wet wind may blow no harder than a warm dry one, but it will seem to.

Just as the actual speed of an automobile may be measured by its speedometer, wind velocity may be measured by an instrument called an anemometer. According to the specifications of what is known as the Beaufort scale, the Weather Bureau of the United States Department of Agriculture gives the following rates for winds corresponding successively to numbers on the Beaufort scale from 0 to 12. When the wind blows less than 1 mile an hour, the air is said to be "calm." "Light air" means a wind rate from 1 to 3 miles per hour; a "slight breeze," from 4 to 7 miles; "gentle breeze," 8 to 12; "moderate breeze," 13 to 18; "fresh breeze," 19 to 24 miles per hour. At 25 miles an hour we have a "strong breeze," which is called a "high wind" from 32 to 38 miles hourly; 39 to 46 miles an hour constitutes a real "gale." When seamen talk about a "strong gale," the weather-man interprets it as a wind blowing between 47 and 54 miles an hour; a "whole gale" is from 55 to 63 miles, and is as severe as most of us care to encounter. A "storm" wind ranges between 64 and 75 miles an hour, and above 75 miles any wind becomes a "hurricane."—*U. S. Department of Agriculture.*